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NATIONAL DAM INSPECTION PROGRAM. BRADFORD CITY NUMBER 2 DAM (ND--ETC(U)

DACW31-79-C-0011

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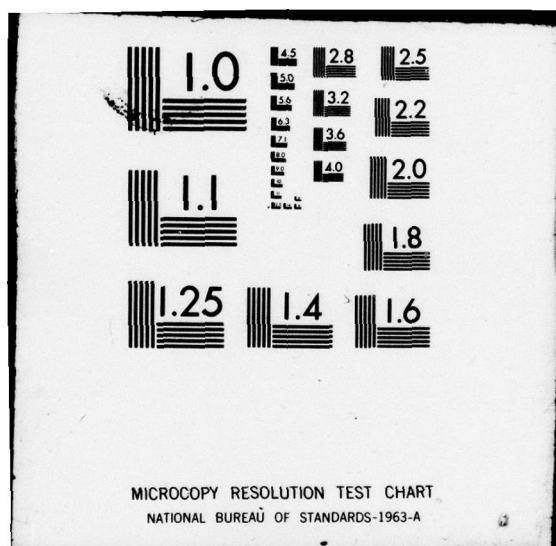
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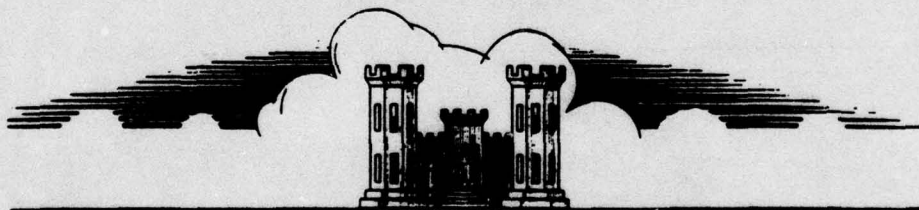
BRADFORD CITY No. 2 DAM

NDI No PA 00024
PennDER No. 42-8

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



prepared for

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

prepared by

MICHAEL BAKER, JR., INC.
Consulting Engineers
4301 Dutch Ridge Road
Beaver, Pennsylvania 15009

February 1979

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OHIO RIVER BASIN

BRADFORD CITY NO. 2 DAM
McKEAN COUNTY, COMMONWEALTH OF PENNSYLVANIA
NDI NO. PA 00024
PennDER NO. 42-8

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

6 National Dam Inspection Program. Brad-
ford City Number 2 Dam (NDI-PA-00024,
PennDER-42-8), Ohio River Basin, Gilbert
Run, McKean County, Pennsylvania. Phase
I Inspection Report.

Prepared for: DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

10 C.Y. / Chen

Prepared by: MICHAEL BAKER, JR., INC.
Consulting Engineers
4301 Dutch Ridge Road
Beaver, Pennsylvania 15009

Date: 11 February 1979

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PREFACE

This report is prepared under guidance contained in the "Recommended Guidelines for Safety Inspection of Dams," for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I Inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Bradford City No. 2 Dam, McKean County, Pennsylvania
NDI No. PA 00024, PennDER No. 42-8
Gilbert Run
Inspected 7 and 8 November 1978

ASSESSMENT OF
GENERAL CONDITIONS

↓
Bradford City No. 2 Dam is a diaphragm earthfill embankment dam with a maximum height of 44 feet and a crest length of 920 feet. Discharge is provided by an uncontrolled chute spillway located at the right abutment. The dam is owned and operated by the Bradford City Water Authority for water supply.

The visual inspection and review of engineering data, performed in November 1978 through January 1979, indicate no serious deficiencies requiring emergency attention. The dam was found to be in fair overall condition at the time of inspection. However, the owner should immediately retain a qualified consultant for additional investigation of certain features, including the effect of the seepage and phreatic surface on the structural stability of the downstream slope and revitalization or reconstruction of the toe drain system in the embankment. It is further recommended that all rodent holes be repaired; a rodent control program be implemented; the upstream slope riprap be repaired; the right bank of the downstream channel be protected with riprap; seepage weirs be installed and monitored for quantity and turbidity of all seepage; and the spillway concrete be properly repaired and maintained as necessary.

↓
~~Hydraulic/hydrologic evaluations, performed in accordance with criteria established by the Baltimore District of the U.S. Army Corps of Engineers for Phase I Inspection Reports,~~ revealed that the spillway will not pass the Probable Maximum Flood (PMF) without overtopping the dam. Further, the spillway is considered "inadequate" because the spillway — — — — — →

will pass approximately 38 percent of the PMF before overtopping and failure is not likely to occur under the 50 percent PMF condition. Therefore, the owner should immediately initiate a detailed engineering study to evaluate the spillway capacity and develop recommendations for remedial measures to reduce the overtopping potential of the dam. The owner should also develop emergency operation and evacuation procedures.

Submitted by:



MICHAEL BAKER, JR., INC.

C. Y. Chen
C. Y. Chen, Ph.D., P.E.
Engineering Manager-Geotechnical

Date: 16 February 1979

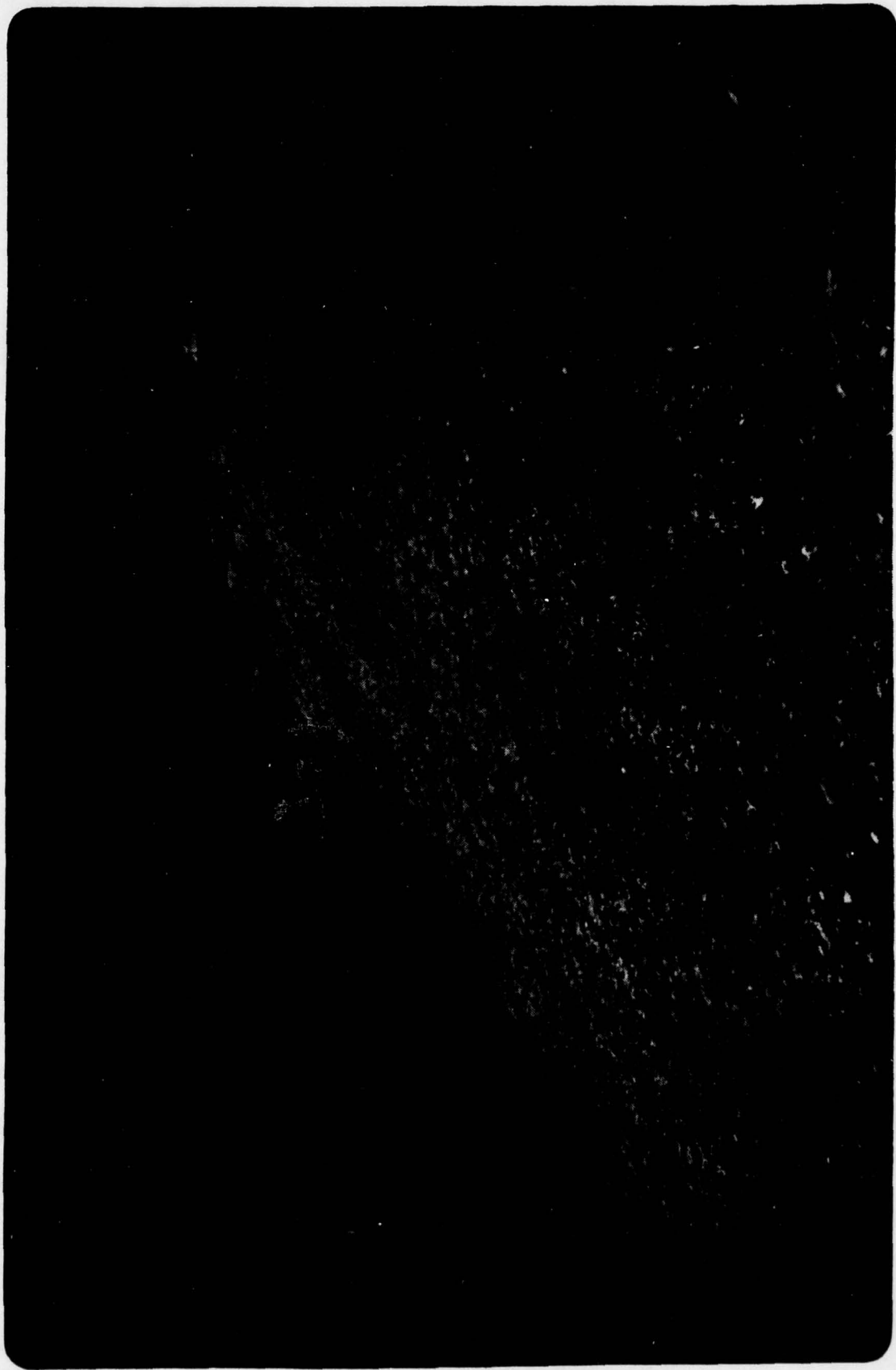
Approved by:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS

G. K. Withers
G. K. Withers
Colonel, Corps of Engineers
District Engineer

Date: 15 Mar 79

BRADFORD CITY No. 2 DAM



Overall View

TABLE OF CONTENTS

	<u>Page</u>
Section 1 - Project Information	1
Section 2 - Engineering Data	5
Section 3 - Visual Inspection	7
Section 4 - Operational Procedures	9
Section 5 - Hydraulic/Hydrologic	11
Section 6 - Structural Stability	13
Section 7 - Assessment, Recommendations/Remedial Measures	16

PLATES

Plate 1 - Location Plan
Plate 2 - Watershed Map
Plate 3 - General Plan of Reservoir
Plate 4 - Plan, Profile, and Section (Through Gate House) of Dam
Plate 5 - Profile and Section of Spillway
Plate 6 - Spillway Repairs (1945)

APPENDICES

Appendix A - Check List - Visual Inspection and Field Sketch
Appendix B - Check List - Engineering Data
Appendix C - Photographs
Appendix D - Hydraulic and Hydrologic Computations
Appendix E - Regional Geology

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
BRADFORD CITY NO. 2 DAM
NDI NO. PA 00024, PennDER No. 42-8

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

- a. Authority - The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.
- b. Purpose of Inspection - The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

- a. Description of Dam and Appurtenances - Bradford City No. 2 Dam consists of a diaphragm earthfill embankment, approximately 44 feet high and 850 feet long, and a chute spillway with a crest width of 68.8 feet. Seepage control is provided by a masonry diaphragm core wall which extends into the underlying soil foundation of the dam. The top width of the core wall is 2 feet and the bottom width of the core wall is 6 feet. The highest section of core wall at the same location as the outlet pipe is approximately 55 feet high, extending from 4 feet below the crest of the dam, through the base of the embankment, and into the underlying soil foundation. The core wall rests on an 18-inch thick, 10-foot wide concrete foundation. The dam was increased in height by 20 feet in the years 1909 through 1913. In increasing the height of dam by 20 feet, the original earthfill dam was used as the toe portion of the upstream slope, in effect, moving the center of the new dam 35 feet downstream from the centerline of the old dam.

The spillway is located at the right abutment of the dam. The spillway crest is 68.8 feet wide with a 3-foot wide bridge pier in the center. The pier serves as a support for a walkway across the spillway. Masonry abutments constructed of sandstone blocks are situated on each side of the spillway crest. The spillway discharge, after passing over the crest, is conducted around a curve, down a straight section, and then down a rapid chute section into the stilling basin.

The outlet works consist of two 20-inch diameter, concrete pipes exiting through the dam approximately 472 feet from the left abutment. One pipe is used for water supply and the other is outletted downstream from the dam. A riser tower is located approximately 55 feet upstream from the centerline of the dam. The controls for the water supply and blow-off pipes are in the tower.

- b. Location - Bradford City No. 2 Dam is located in Bradford Township, McKean County, Pennsylvania. The dam is located on Gilbert Run, approximately 4 miles upstream (west) from the City of Bradford. Gilbert Run joins Marilla Brook approximately 1/2 mile downstream from the dam. Marilla Brook flows into the West Branch of Tunungwant (Tuna) Creek an additional 2.5 miles downstream. Tuna Creek then flows through the center of the City of Bradford.
- c. Size Classification - The maximum height of the dam is 44 feet. The reservoir volume to the top of dam at El. 1705.9 feet is 760 acre-feet. Therefore, the dam is in the "Intermediate" size category.
- d. Hazard Classification - More than a few lives would likely be lost in the event of a failure of the dam. Therefore, the dam is considered in the "High" hazard category.
- e. Ownership - The dam and reservoir are owned by the Bradford City Water Authority, 24 Kennedy Street, Bradford, Pennsylvania 16701. The present water authority chairman is Mr. O. C. Knott. The present water authority superintendent is Mr. Pat A. Nuzzo.
- f. Purpose of the Dam - The dam is used for water supply storage.
- g. Design and Construction History - The dam was constructed in 1886 by J. A. Seymore. The embankment was raised 20 feet in the years 1909 to 1913 under the supervision of A. F. Bannon, Jr., then City Engineer, while Mr. B. A. Wise acted in the capacity of field engineer for the city. North Western Construction Company was contractor for the later construction.

- h. Normal Operational Procedures - The reservoir is maintained at approximately the same level all year. Personnel of the water authority visit the chlorinator house downstream from the dam daily to regulate and maintain the chlorine for water supply purposes. Typically, the dam is examined twice a week to determine the extent of routine maintenance required.

1.3 PERTINENT DATA

- a. Drainage Area - The drainage area of Bradford City No. 2 Dam is 4.49 square miles.
- b. Discharge at Dam Site - The maximum flow at the dam site over the spillway is unknown. The ungated spillway capacity at average top of dam elevation is approximately 2500 c.f.s.
- c. Elevation [feet above Mean Sea Level (M.S.L.)] -
- | | |
|----------------------------------|--------|
| Design Top of Dam - | 1706.0 |
| Minimum Top of Dam - | 1705.9 |
| Average Top of Dam - | 1706.3 |
| Maximum Pool - | 1706.3 |
| Normal Pool - | 1701.0 |
| Streambed at Centerline of Dam - | 1662.0 |
| Maximum Tailwater - | N.A. |
- d. Reservoir (feet) -
- | | |
|--------------------------|------|
| Length of Maximum Pool - | 2600 |
| Length of Normal Pool - | 2300 |
- e. Storage (acre-feet) -
- | | |
|--------------------------------------|-----|
| At Top of Dam (El. 1705.9 ft.) - | 760 |
| At Spillway Crest (El. 1701.0 ft.) - | 553 |
- f. Reservoir Surface (acres) -
- | | |
|-----------------------------------|------|
| Top of Dam (El. 1706.3 ft.) - | 46.0 |
| Spillway Crest (El. 1701.0 ft.) - | 38.6 |
- g. Dam -
- | | |
|--------------------------|-----------|
| Type - | Earthfill |
| Length (feet) - | 920 |
| Height (feet) - | 44 |
| Top Width (feet) - | 12 |
| Side Slopes - Upstream - | 2H:1V |
| Downstream - | 2H:1V |

Zoning - The design drawing (see Plate 4) for the flattening of the downstream slope indicates the original embankment was constructed with a central zone. This original embankment was left as the toe of the upstream slope during the raising of the embankment in 1909 through 1913. The remaining portion of the upstream half of the dam was constructed of a "natural mixture of clay and sand excavated at the upper end of the reservoir," according to the 1915 report prepared by the Water Supply Commission of Pennsylvania [predecessor of Pennsylvania Department of Environmental Resources (PennDER)].

Impervious Core - Stone-masonry core wall consisting of sandstone blocks laid with portland cement mortar. Maximum thickness is 6 feet at the base and minimum thickness is 2 feet at the top.

Cutoff - At the deepest section of the embankment the stone-masonry core wall was constructed 15 feet below the original ground surface.

h. Diversion and Regulating Tunnel - None

i. Spillway -

Type - Overflow

Width of Weir (feet) - 65.8

Crest Elevation (feet M.S.L.) - 1701.0

Gates - None

Downstream Channel - The downstream channel consists of a concrete channel 69 feet wide with a long radius curve (in plan view). The channel then exits into a rapid chute. A 22-foot by 30-foot stilling basin is located at the end of the chute. The discharge then enters a natural channel to the original Gilbert Run channel. The total length from spillway crest to stilling basin is 268 feet.

j. Regulating Outlets - A 20-inch concrete pipe running through the embankment is located approximately 500 feet from the left abutment. A control valve is located in the riser tower 55 feet upstream from the center of the dam.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Review of information included:

- 1) Pennsylvania Department of Environmental Resources (PennDER) file for Bradford City No. 2 Dam:
 - a) "Report Upon the Number 2 Dam of the Bradford Municipal Water Works" prepared by the Water Supply Commission of Pennsylvania (predecessor of PennDER) and dated 11 August 1915.
 - b) Various inspection reports by state personnel.
 - c) Various correspondence.
 - d) Memorandums.
 - e) Permit applications for various repairs.
 - f) Various permits for making repairs.
 - g) Various photographs as a result of the inspections performed.
- 2) Original drawings obtained from Mr. Pat Nuzzo, Superintendent, Bradford City Water Authority (some of the drawings are enclosed in this report as Plates 3 through 8).

The last inspection of the dam was performed on 20 September 1977 by Mr. Walter Leidig of PennDER. He indicated in his report that the dam was in good general appearance, but there was "some minor heaving in the riprap on the upstream face, minor seepage downstream approximately 200 feet from the right abutment, and minor seepage at the center of the dam." He also indicated that the concrete in the spillway needed repair and recommended a letter to the water authority requesting them to repair the concrete in the spillway chute slabs.

2.2 CONSTRUCTION

The original embankment was constructed in 1886 by J. A. Seymore. Very little information is available concerning this construction except for the information incorporated into later design drawings for the additional 20 feet of embankment. The increase in height of the embankment occurred during the years 1909 to 1913 under the supervision of A. F. Bannon, Jr., City Engineer. Mr. B. A. Wise was the field engineer for the city during the construction. North Western Construction Company was contractor for the later construction. Information contained in the 1915 report by the Water Supply Commission of Pennsylvania indicates that the techniques employed for construction were very excellent for that time, including removing the topsoil and plowing the ground to insure bonding of the old and new materials. The fill was obtained from the upper end of the reservoir and consisted primarily of clay and sand. Additional information contained in the 1915 report states that the spillway location was changed during the embankment raising. The original spillway was located 100 feet from the left abutment of the old dam (or 200 feet from the left abutment of the new embankment) and consisted of timber. The present spillway is located at the right abutment of the dam.

2.3 OPERATION

Operation records are not recorded for Bradford City No. 2 Dam and Reservoir. The Bradford City Water Authority is responsible for maintenance and operation of the dam and appurtenant structures.

2.4 EVALUATION

- a. Availability - The information reviewed consisted of PennDER's file on the dam and information obtained from the owner. Considering the age of the structure, it is doubtful any additional information is available.
- b. Adequacy - The readily available information and the results of the field inspection are considered adequate for a Phase I Investigation of the dam.
- c. Validity - No indications were present during the field inspection to doubt the validity of the information reviewed.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

- a. General - The inspection was performed on 7 and 8 November 1978. The weather was slightly rainy on the 7th, but the rain ceased on the afternoon of the 8th. The lake was at normal pool during the inspection. The dam and appurtenant structures were found to be in fair overall condition. Noteworthy deficiencies are described briefly in the following paragraphs. The complete visual inspection check list and the field sketch are presented in Appendix A.
- b. Dam - Seepage was observed exiting through a rock drain placed at the junction of the toe of the downstream slope and the toe of the left abutment hillside. The rate of flow was estimated at 1 g.p.m. at the time of the visual inspection. No fines were transmitted by the water and no piping cavities were observed. Seepage was also observed at a location 612 feet right of the left abutment and near the toe of the embankment. The seepage was flowing at an estimated 0.5 g.p.m. and was not carrying fine material. The vegetation indicated that this seepage area has existed for a long time.

The toe drain system was inspected; many of the outlets are either covered with soil or are in a general state of disrepair. The design drawings indicate the toe drains extend along the downstream toe of the embankment. Outlets carrying the flow below the downstream berm (along the toe of the embankment) are spaced approximately 50 feet apart. The toe drain outlet located approximately 230 feet from the left abutment was flowing at an estimated rate of 5 g.p.m. The water exiting from the drain appeared clear and was not carrying any fine material. The toe drain outlet located approximately 265 feet from the left abutment was flowing at a rate of approximately 1 g.p.m. This outlet flow also appeared clear and was not carrying any fine material.

A depression, approximately 1.5 feet deep and 2 feet by 5 feet in plan, is located near the toe of the downstream slope approximately 315 feet right of the left abutment. Since this is the location of a toe drain outlet pipe that is no

longer functional, it is conjectured that the depression is the result of a collapsed toe drain outlet pipe and/or internal erosion of embankment material through the outlet pipe.

The visual inspection also disclosed several locations in the dam where animals had been burrowing. Burrows were numerous in the berm at the toe of the downstream slope and especially in the area from 500 feet to 520 feet right of the left abutment. These holes should be repaired.

The riprap at two locations needs to be reworked. These areas are 675 feet and 725 feet right of the left abutment. There is a rodent hole 725 feet from the right abutment which needs to be filled prior to reworking the riprap.

- c. Appurtenant Structures - The concrete overflow spillway located at the right abutment of the dam has signs of cracking and minor spalling. Also, the spillway channel exiting into the rapid chute has signs of deterioration. This deterioration is not abnormal for the age of the concrete and the water authority has used asphalt sealer to patch the cracks. However, continued maintenance and repair of the concrete areas will be necessary in the future to prevent rapid deterioration and total replacement of the areas.

No significant problems were observed in the outlet works, outlet head wall or outlet channel. The owner indicated that the blow-off pipe is opened twice a year to insure proper operation.

- d. Reservoir Area - No problems were observed in the reservoir area.
- e. Downstream Channel - The right side of channel immediately downstream from the stilling pool is eroded. Placement of riprap protection at this location will help reduce the erosion. No obstructions or other problems were observed in the downstream channel. There are approximately 20 residences located within the first mile downstream from the dam. There are several hundred homes located downstream along Marilla Brook and the West Branch of Tuna Creek. Tuna Creek then flows through the City of Bradford (1970 census approximately 13,000 people).

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no formal written procedures for reservoir operation or emergency downstream evacuation in the event of impending catastrophe.

It is recommended that a formal emergency procedure be prepared and prominently displayed, and furnished to all personnel. This should include:

- 1) Procedures for evaluating inflow during periods of emergency operation.
- 2) Procedures for rapid drawdown of the reservoir under emergency conditions.
- 3) Who to notify, including public officials, in case evacuation from the downstream area is necessary.

In addition, the owner should assist public officials in developing an emergency evacuation plan for areas which will be affected in the event of a dam failure.

4.2 MAINTENANCE OF DAM

The Bradford City Water Authority is responsible for maintenance of the dam. Generally, the maintenance procedures of the water authority are considered adequate. However, a rodent control program should be implemented and periodic maintenance of all concrete structures and channels should be performed.

4.3 MAINTENANCE OF OPERATING FACILITIES

The only operating facilities associated with the dam are the controls for the water supply pipe and the blow-off pipe. The blow-off pipe is typically operated by the water authority twice a year to check its condition and operational adequacy. Maintenance is presumably performed at this time to ensure continued operation.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no warning system or procedure in the event of a impending dam failure. An emergency warning procedure should be developed and/or a warning system installed for proper notification of downstream residents as recommended in paragraph 4.1.

4.5 EVALUATION OF OPERATIONAL ADEQUACY

The maintenance procedures for Bradford City No. 2 Dam are considered adequate except for the deficiencies noted. The operating facilities are considered functional. Care and maintenance of these facilities should continue in the future.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

- a. Design Data - No hydrologic or hydraulic design data were available for the preparation of this report. All calculations used in the analysis were generated during the course of this study.

In a report by the Water and Power Resources Board dated 2 August 1944, it was stated that the spillway capacity of 2278 c.f.s. was entirely too small according to the standards at that time. The spillway capacity was verified as part of this inspection report.

- b. Experience Data - The greatest flood of record at the reservoir site occurred during the period of 18-20 July 1942. During a period of 41 hours, 4.75 inches of rainfall was recorded causing the reservoir to rise from a level of 26 inches below the crest to 10 inches above the crest. No other detailed rainfall/reservoir stage records were available for the preparation of this report.
- c. Visual Observations - On the dates of the inspection, no condition was observed that would indicate that the spillway of the dam could not operate satisfactorily in the event of a flood.
- d. Overtopping Potential - The Bradford City No. 2 Dam is classified as a "High" hazard-"Intermediate" size dam requiring evaluation for a spillway design flood (SDF) equal to the Probable Maximum Flood (PMF). The spillway consists of a 68.8-foot wide, rectangular shaped, approach channel and control weir exiting into a chute channel. A 3-foot wide walkway bridge pier is located near the center of the spillway crest reducing the effective width to 65.8 feet.

The hydrologic and hydraulic capabilities of the reservoir and spillway were evaluated by routing the PMF and ratios of the PMF through the reservoir with the aid of the U.S. Army Corps of Engineers Flood Hydrograph Package, HEC-1. The PMF and 1/2 PMF were both found to overtop the minimum top of dam by depths of 1.7 and 0.7 feet, respectively. The results of this analysis indicate that the reservoir and spillway are capable of passing a flood approximately equal to 38 percent of PMF without overtopping the dam.

- e. Spillway Adequacy - The dam as outlined in the above analysis would be overtopped by the 1/2 PMF. The criteria, for spillway adequacy determination, requires an estimate of the likelihood of dam failure during overtopping by 1/2 PMF conditions. Therefore, the following conditions were used as the limiting criteria which are likely to cause failure of this dam.

- 1) Depth of overtopping in excess of 1.0 foot.
- 2) Duration of overtopping in excess of 4 hours.*
- 3) Approximate maximum velocity of overtopping in excess of 4 f.p.s.*

The overtopping analysis of this dam yielded the following values.

- 1) 0.7 foot
- 2) 3.5 hours
- 3) 3.8 f.p.s.

Therefore, dam failure during the above 1/2 PMF conditions is not likely to occur and the spillway is assessed as "inadequate."

The hydrologic determinations presented in this Phase I Inspection Report are based upon the use of a Snyder's unit hydrograph developed from coefficients determined by the Baltimore District of the U.S. Army Corps of Engineers. Due to the limited number of gaging stations available in this hydrologic region and the wide variation of watershed slopes, the Snyder's coefficients may yield results of limited accuracy for this watershed. As directed, a further refinement of these coefficients is beyond the scope of this Phase I investigation and, therefore, must be addressed by the dam owner's engineering consultant during the detailed investigation as suggested in the "Assessment of General Conditions."

In addition, the conclusions presented pertain to present conditions, and the effect of future development on the hydrology has not been considered.

*These parameters will vary according to cover and material conditions of the dam crest.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

- a. Visual Observations - The seepage area observed at approximately 612 feet right of the left abutment is not considered to be immediately hazardous to the structural stability of the embankment according to the conditions that were present at the time of inspection. However, the area should be observed frequently in the near future. It is conjectured that this seepage is related to the improper functioning of the toe drain system. It is recommended that the owner retain a consultant experienced in earth embankment dams to develop recommendations for the revitalization or reconstruction of the toe drain system in the earth embankment. As a part of this work, the consultant should investigate the above mentioned seepage and investigate the depression at the toe of the slope approximately 315 feet right of the left abutment. The rodent holes in the downstream berm should also be examined and repaired when the toe drain is repaired.

The seepage at the toe of the left hillside and the toe of the embankment junction has been flowing since construction of the dam. Material was dumped into the corner of the reservoir in 1922 to try to stop this flow. A 1924 inspection report indicates this flow ceases when the reservoir is drawn down 8 feet below normal pool level. This seepage area is not considered detrimental according to the conditions present at the time of the visual inspection; however, seepage weirs should be installed to measure all seepage quantities and the turbidity of the seepage observed. If conditions indicate the necessity, remedial action should be taken.

- b. Design and Construction Data - No design information or stability computations were available. Considering the age of the structure and state-of-the-art in geotechnical engineering at the time, it is theorized that the design was based on local experience with the materials available in the region. One important feature in this dam was the revision of the downstream slope from 1.5H:1V to 2H:1V. This revision increased the factor of safety of the downstream slope stability; especially since subsequent to the 1913 increase of embankment height to 40 feet, the downstream slope was sloughing

until the slope was flattened in 1921. General information concerning the construction of the slope modification was unavailable. Information of particular importance would be the proper preparation of the existing slope by scarifying to incorporate an adequate bond between the new and existing fill. Also, any existing planes of slippage from the previous sloughage should have been repaired or roughened. On 20 July 1933, the dam was inspected by an engineer of the Water and Power Resources Board and three test pits were examined. The locations were not noted; however, the engineer did indicate that "the fill carried a large percentage of clay, with considerable stone and some sand; however, it was poorly placed, leaving the embankment more or less porous due to insufficient rolling or the use of excessively heavy layers. [Heavy in this context probably means excessively thick layers.] Two of the pits showed some seepage from the reservoir." Given this description it is probable that the construction of the additional fill on the slope was performed by end dumping of the material from the crest of the embankment with only a sufficient amount of compaction and grading to prepare the slope at the proposed inclination.

Given the uncertainties in design and construction of Bradford City No. 2 Dam, it is recommended that a quantitative assessment of the structural stability of the dam be performed in the near future.

- c. Operating Records - No information concerning operation records affecting structural stability were available for review.
- d. Post-Construction Changes - As previously presented in this report, the downstream slope was revised in 1921 from 1.5H:1V to 2H:1V. While this modification increased the structural stability of the downstream slope, it could not be determined whether this modification was sufficient to meet current design standards for factors of safety for stable slope inclinations of dam embankments.
- e. Seismic Stability - Bradford City No. 2 Dam is located near the boundary between Seismic Zone 1 and 2 according to the "Seismic Zone Map of the Contiguous United States," Figure 1, Page D-30, "Recommended Guidelines for Safety Inspection of Dams." Both of these zones are considered to be zones of low seismic activity. Experience indicates

that dams located in these zones will have adequate stability under seismic loading conditions if they have adequate stability under static loading conditions. As indicated in paragraph 6.1.b., further assessment of the static stability is recommended. If the evaluation and subsequent recommendations provide sufficient static stability factors of safety, then Bradford City No. 2 Dam will have sufficient seismic stability.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

- a. Safety - There are no findings, as a result of this inspection, from which a detrimental assessment can be rendered. However, the nature and potential implications of problems previously noted in this report are such that additional investigations of the structural stability and toe drain system are considered necessary. More detailed recommendations in this regard are presented in paragraph 7.2.

The spillway capacity was analyzed using the procedures presented in paragraphs 5.1.d. and 5.1.e. The analysis determined that the spillway will not pass the PMF without overtopping the dam. Based upon the routings, it was estimated that the spillway will pass approximately 38 percent of the PMF before overtopping will occur. Based on this observation, as well as others noted in Section 5; the spillway is considered "inadequate."

- b. Adequacy of Information - The information available and the observations made during the field inspection are considered sufficient for this Phase I Inspection Report.
- c. Urgency - The owner should immediately initiate further investigation as discussed in paragraph 7.1.d.
- d. Necessity for Additional Data/Evaluation - The analyses and assessments performed in connection with this Phase I Inspection Report have indicated the need for further investigation of the following items:
- 1) Additional evaluation of the spillway capacity should be performed and recommendations should be developed to increase spillway capacity.
 - 2) A quantitative analysis of the structural stability of the downstream slope should be performed, particularly in connection with the seepage conditions. Piezometers should be installed to determine the phreatic surface within the embankment. This analysis should result in recommendations for remedial work as necessary.

- 3) A study of the revitalization or reconstruction of the toe drain system should be initiated.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

The inspection and review of information revealed certain items of work which should be performed immediately by the owner. These include:

- 1) The owner should initiate an engineering study to further evaluate the spillway capacity and develop recommendations for increasing the spillway capacity as necessary.
- 2) The owner should initiate an engineering study to provide a quantitative assesment of the downstream slope stability and develop recommendations for remedial action as necessary. Piezometers to measure the phreatic surface in the embankment should be installed in conjunction with this study.
- 3) The owner should initiate an engineering study for the revitalization/reconstruction of the toe drain system in the embankment.
- 4) Development of emergency operations procedures for the reservoir including:
 - a) How to operate the dam during an emergency operation.
 - b) Procedures for evaluating inflow during periods of emergency operation.
 - c) Procedures for rapid drawdown of the reservoir under emergency conditions.
 - d) Who to notify, including public officials, in case evacuation from the downstream area is necessary.

In addition, the owner should assist public officials in developing an emergency evacuation plan for areas which will be affected in the event of a flood or dam failure.

The inspection and review of information revealed other items of work which should be accomplished in the near future by the owner. These include:

- 1) The repair of all rodent holes in the dam, including the downstream berm, and establishment of a rodent control program.
- 2) The localized repair of riprap on the upstream slope.
- 3) Placement of adequate riprap protection along right bank of the downstream channel below the stilling basin.
- 4) The installation of seepage weirs at all locations of seepage. All weirs should be monitored and a record kept of all seepage quantities and turbidity. If conditions indicate the necessity, remedial measures should be taken.
- 5) Continued maintenance and repair of spillway concrete with proper replacement as necessary.

PLATES

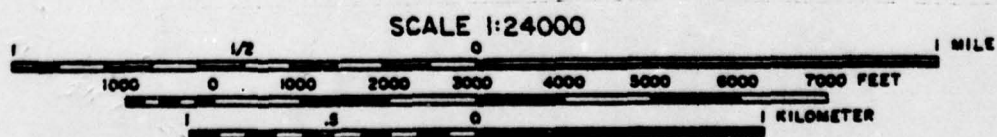
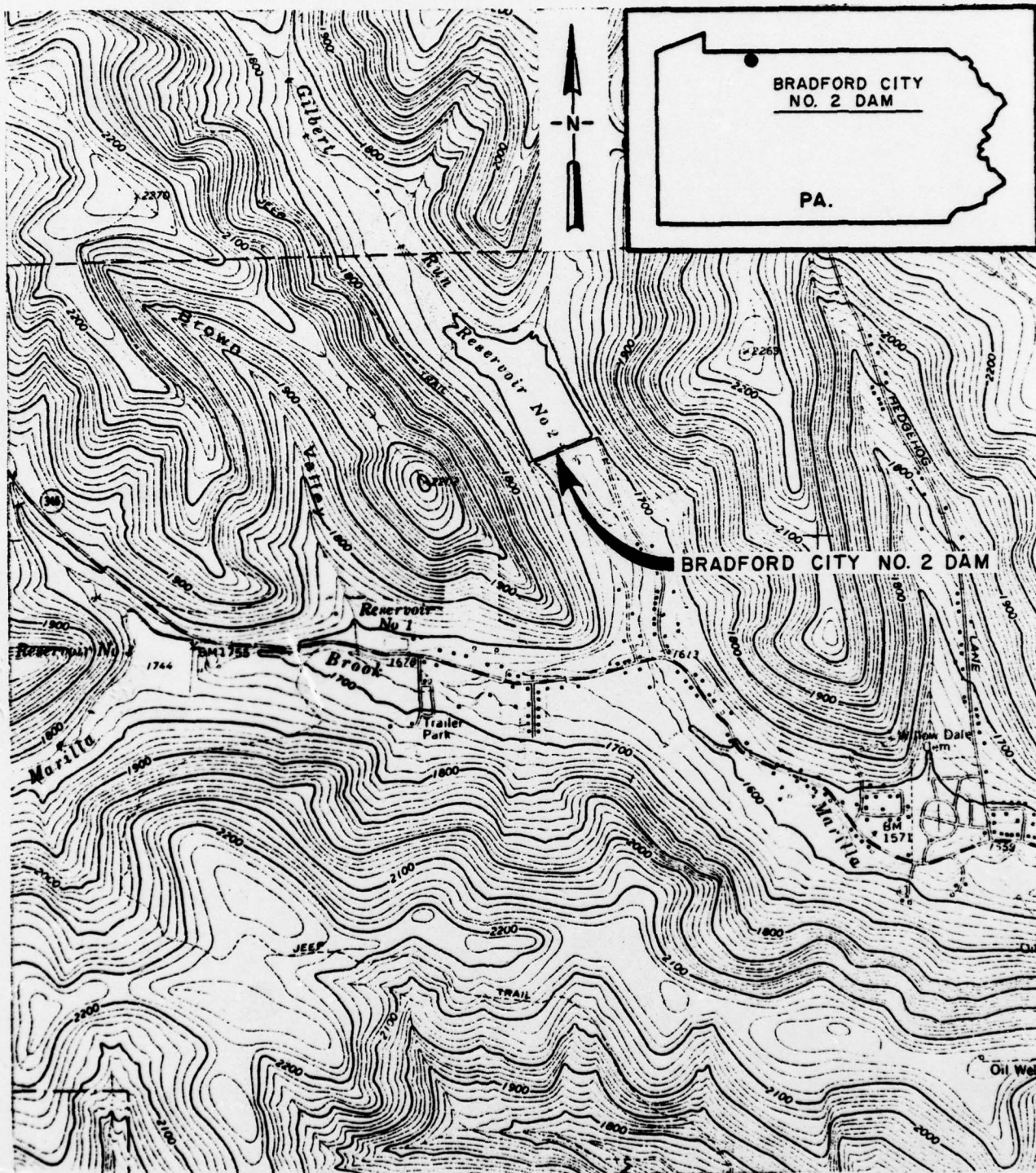


PLATE I LOCATION PLAN
BRADFORD CITY NO. 2 DAM

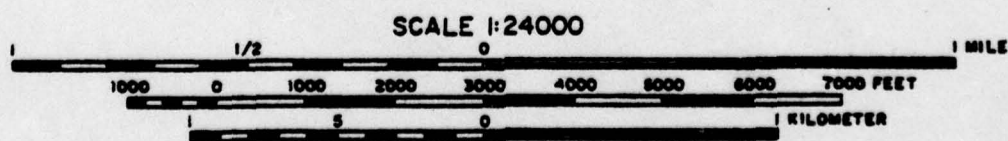
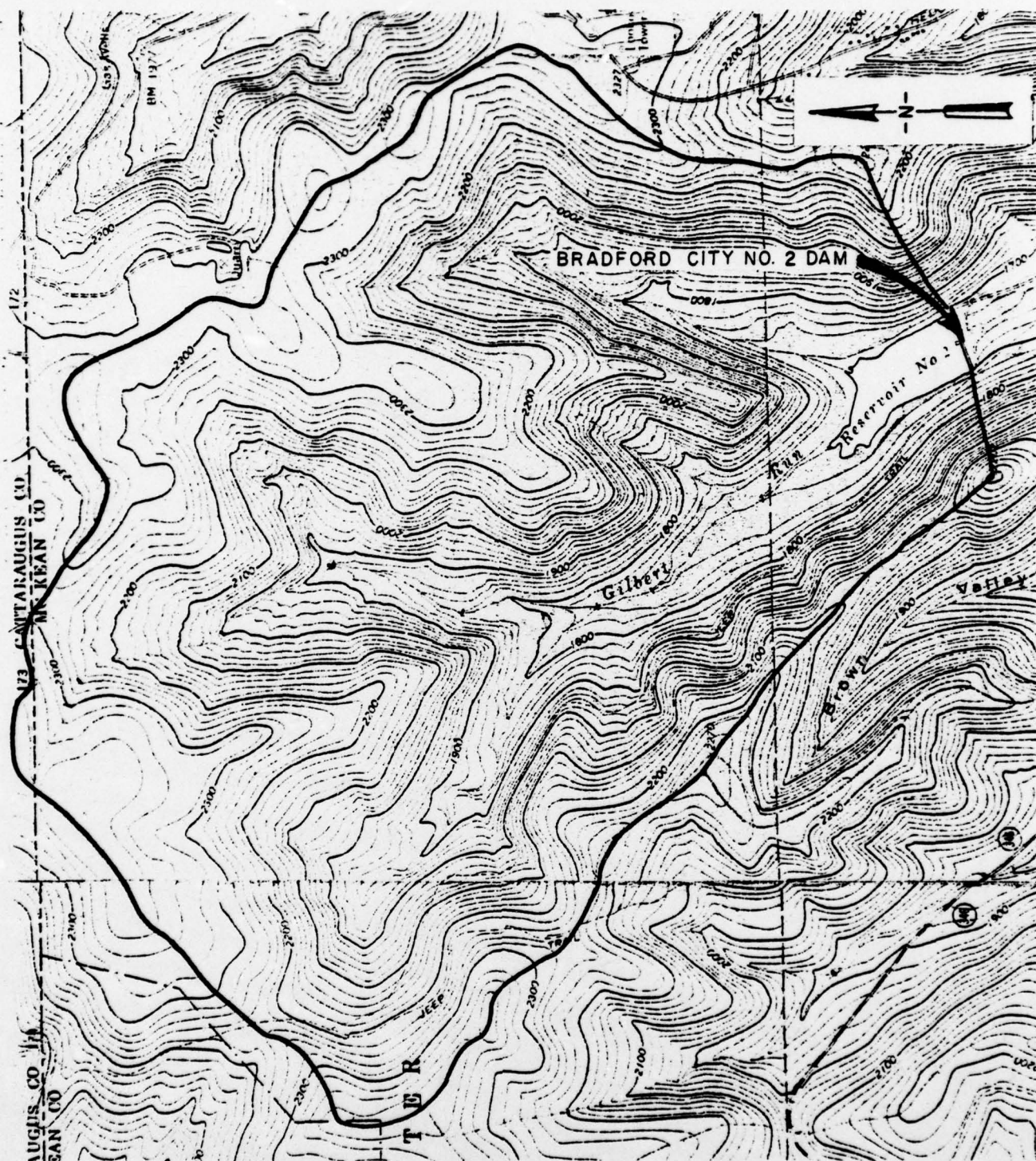
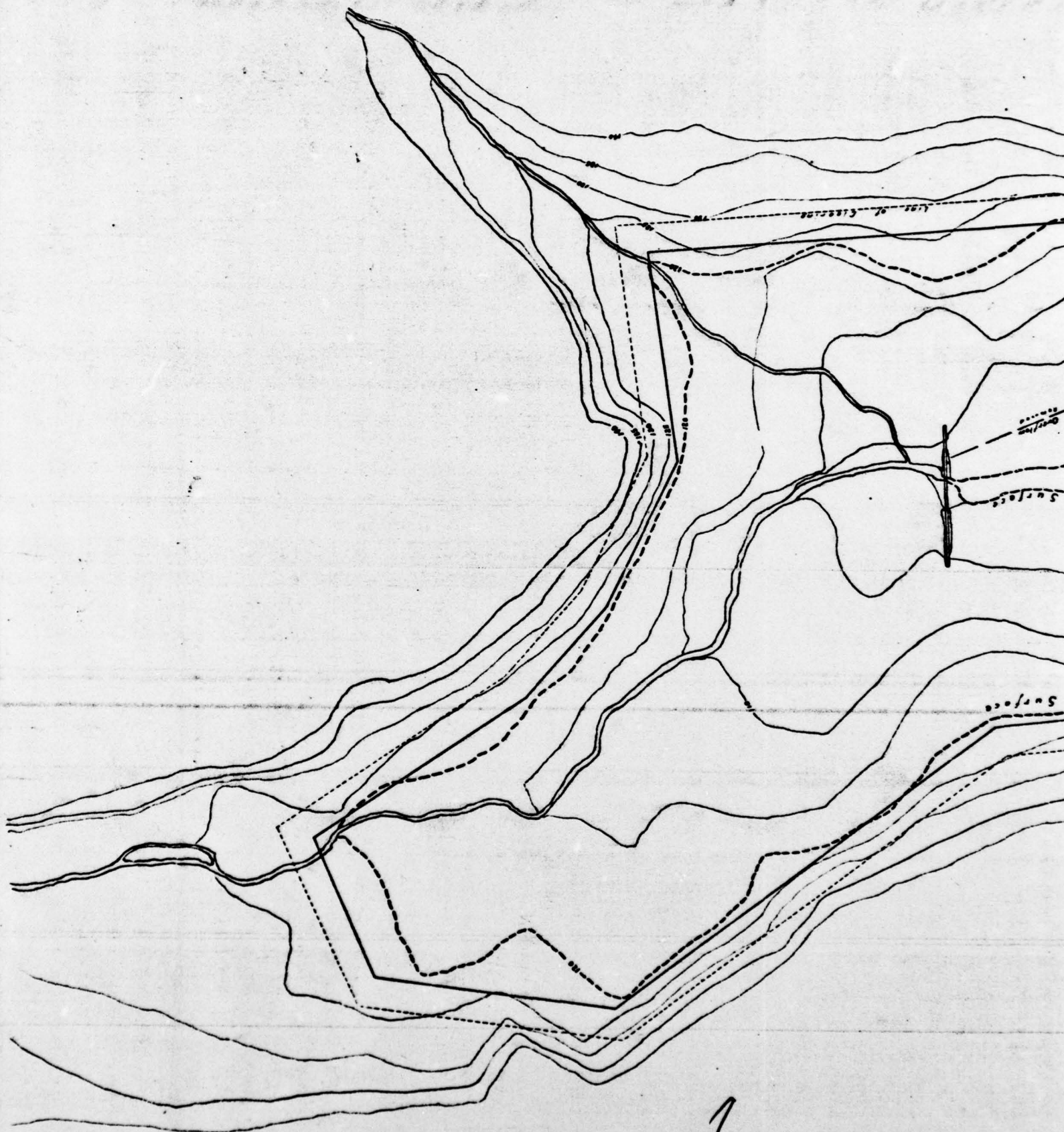
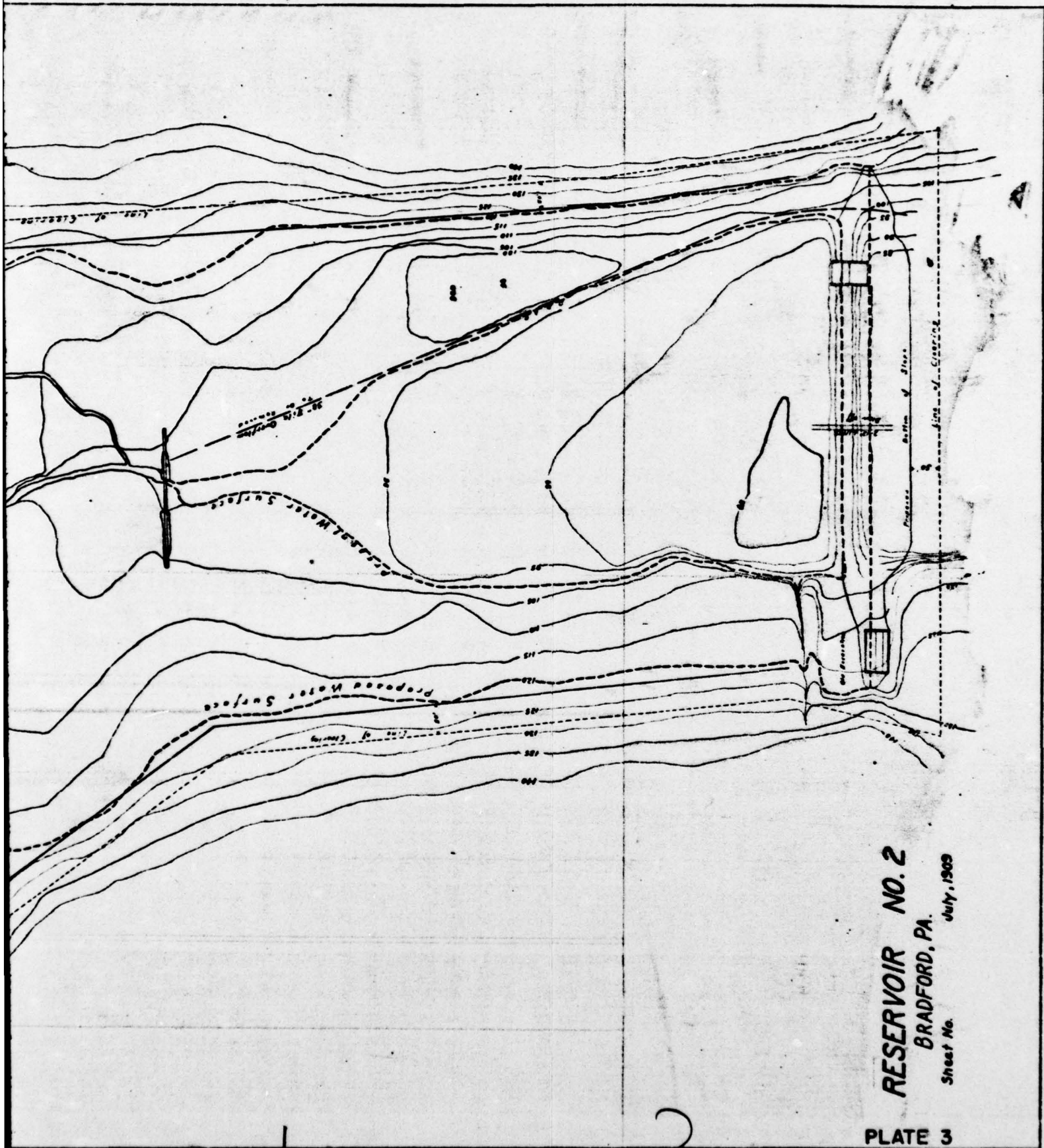


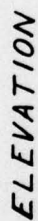
PLATE 2 WATERSHED MAP
BRADFORD CITY NO. 2 DAM





RESERVOIR NO. 2
BRADFORD, PA.
Sheet No. July, 1903

PLATE 3



CITY OF BRADFORD, PENNA.

ENGINEERING DEPARTMENT

PLAN - No. 2 RESERVOIR DAM

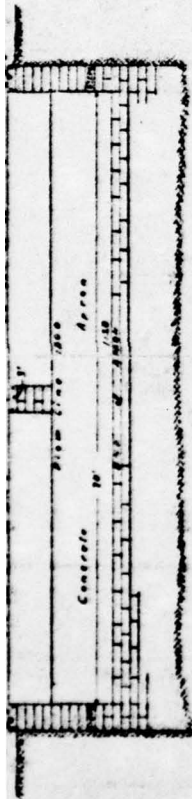
SHOWING APPROX. FLATTENING LOWER SLATE

Scale 500 ft. Sec. 1 to 1 inch. Feb. 24 - 20

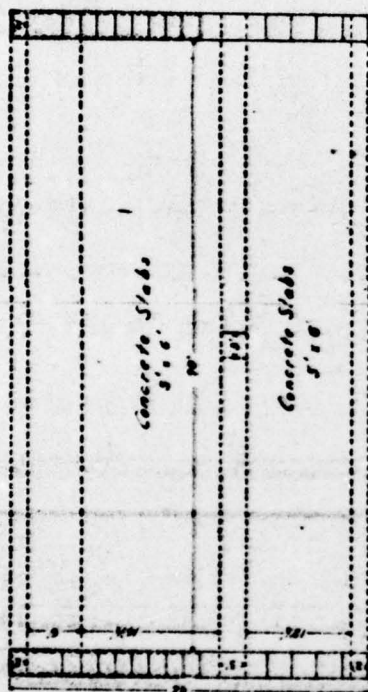
172

May 16

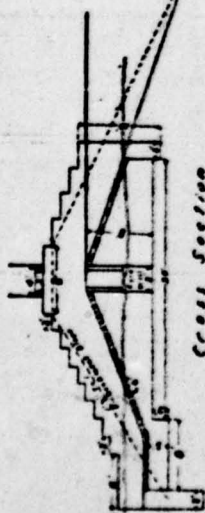
DeMott



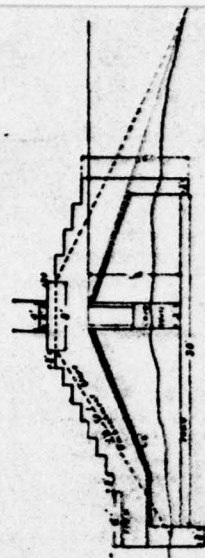
ELEVATION -- SPILLWAY
Scale 1"=10'



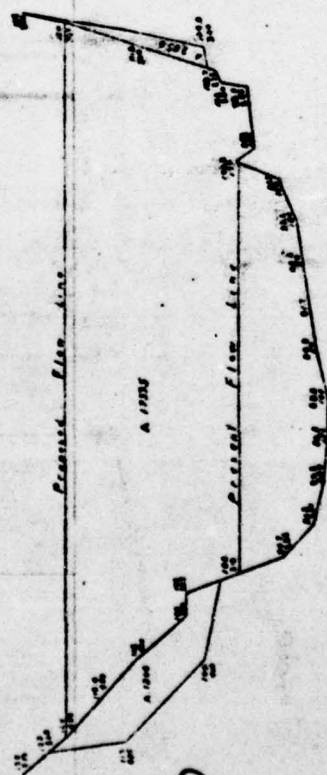
Plan



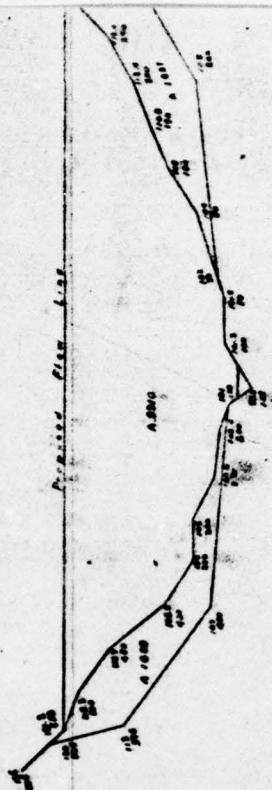
Cross Section
West Abutment



Cross Section
East Abutment



Section of Reservoir at Station 5
Scale - 100' Horizontal 10' Vertical



Section of Reservoir at Station 10
Scale - 100' Horizontal 10' Vertical

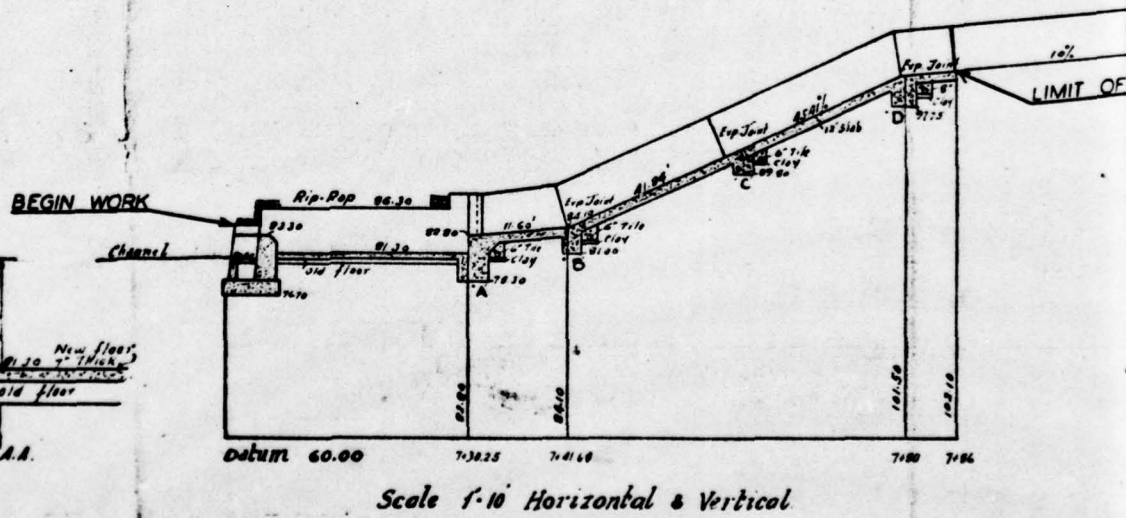
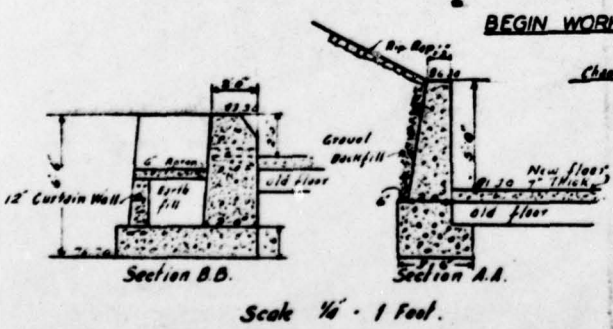
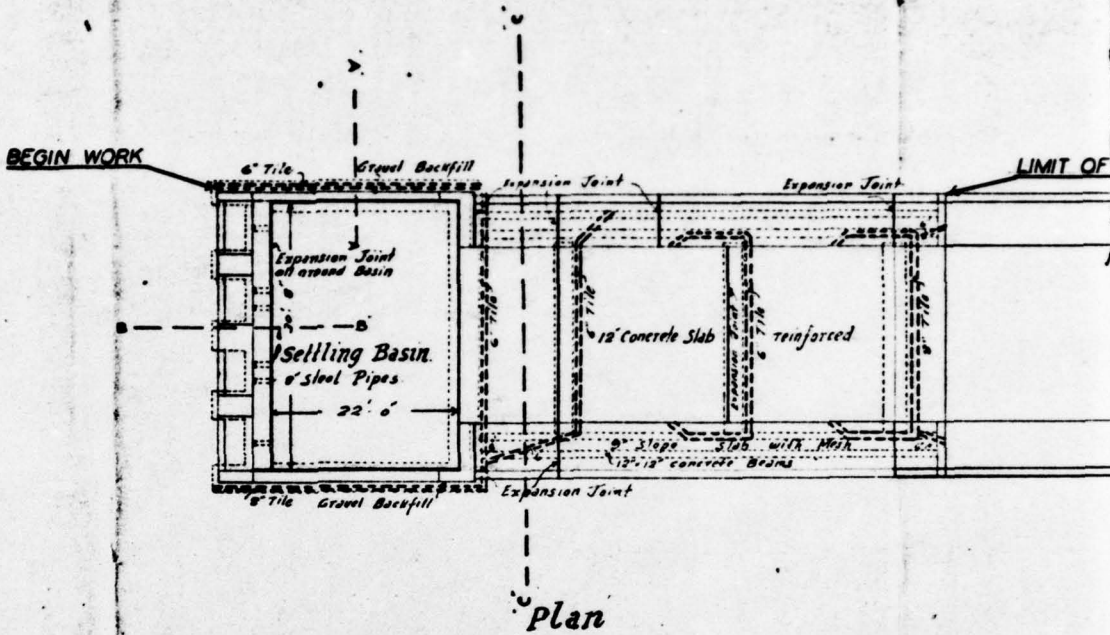
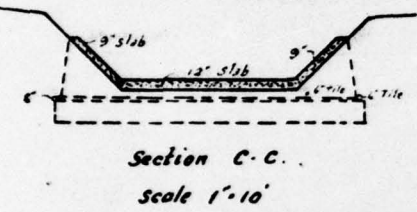
RESERVOIR NO. 2

BRADFORD, PA.

July, 1909.

Sheet No. 3

M. J. Bannan
Engineer



2

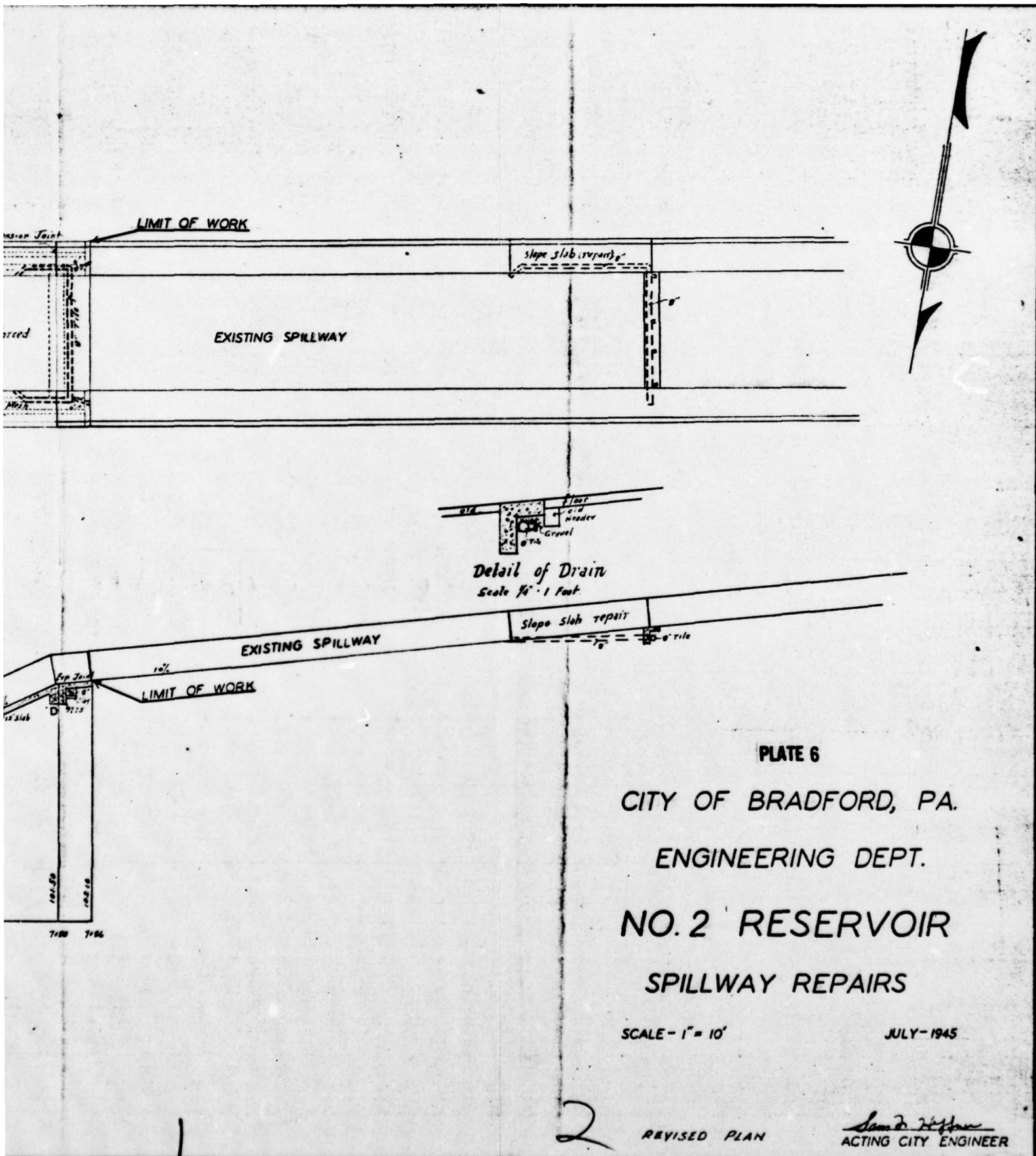


PLATE 6

CITY OF BRADFORD, PA.

ENGINEERING DEPT.

NO. 2 RESERVOIR

SPILLWAY REPAIRS

SCALE - 1" = 10'

JULY - 1945

2

REVISED PLAN

Sam D. Hoffman
ACTING CITY ENGINEER

APPENDIX A

CHECK LIST - VISUAL INSPECTION
AND FIELD SKETCH

Check List
Visual Inspection
Phase 1

Name of Dam Bradford City No. 2 Dam County McKean State PA Coordinates Lat. N 41°57.7'
 NDI # PA 00024 Long. W 78°43.4'
 PENNDEP # 42-8

Date(s) Inspection 7 and 8 November 1978 Weather Rainy, Cool Temperature 45°F. +

NOTE: Station 0+00 was at the left abutment of the dam, and the stationing referenced in this check list was performed during the visual inspection of the dam.

Pool Elevation at Time of Inspection 1701 ft. M.S.L.* Tailwater at Time of Inspection 1662.8 ft. M.S.L.*
 *Elevation 1701 ft. (U.S.G.S. datum) assumed at normal pool.

Inspection Personnel:

Michael Baker, Jr., Inc.:

Thomas W. Smith
 James G. Ujinski
 Rodney E. Holderbaum

Owner's Representatives
 (Bradford City Water Authority):

Pat Nuzzo, Superintendent
 Dave Maben, Foreman

R. E. Holderbaum Recorder

CONCRETE/MASONRY DAMS (N/A)

Name of Dam: BRADFORD CITY NO. 2

NDI # PA 00024

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
LEAKAGE		
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS		
DRAINS		
WATER PASSAGES		
FOUNDATION		

CONCRETE/MASONRY DAMS (N/A)

Name of Dam: BRADFORD CITY NO. 2

NDI # PA 00024

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES		
STRUCTURAL CRACKING		
VERTICAL AND HORIZONTAL ALIGNMENT		
MONOLITH JOINTS		
CONSTRUCTION JOINTS		

EMBANKMENT

Name of Dam: BRADFORD CITY NO. 2
 NDI # PA 00024

<u>VISUAL EXAMINATION OF</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
SURFACE CRACKS	No surface cracks were observed.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Small depression at toe of slope at approximate Station 3 + 15. Appears to be from collapse of the toe drain outlet pipe and/or internal erosion. It appears to have stabilized.	Should be examined as a part of the revitalization of the toe drain system.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	The lowest elevation of the top of the dam is near approximate Stations 6 + 00 to 7 + 00. The embankment at this location is 5 ft. above the spillway crest.	Not considered detrimental and is only 0.3 ft. below the average top of dam El. 1706.3 ft.
RIPRAP FAILURES	Area at approximate Station 6 + 75 where riprap needs to be reworked. Rodent hole at approximate Station 7 + 25 in riprap.	Repair rodent hole and rework riprap at both locations.

EMBANKMENT

Name of Dam: BRADFORD CITY NO. 2
 NDI # PA 00024

VISUAL EXAMINATION OF		OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANIMAL/RODENT HOLES		Several animal/groundhog/rodent holes or burrows were observed in the embankment. The most severe area was at approximate Stations 5 + 00 to 5 + 20 in the berm below the toe of the embankment.	This area should be repaired; perhaps at the same time the toe drain system is repaired. All holes in the berm should be opened for examination and the cause determined.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM		No problems observed.	
ANY NOTICEABLE SEEPAGE		Yes. Seepage was noticed at two separate locations. At approximate Station 6 + 12 at the toe of the embankment, seepage was flowing at an estimated 0.5 g.p.m. Seepage was noticed at approximate Station 0 + 67 at the junction of the toe of the embankment and the toe of the left hillside. The quantity of flow was estimated at 1 g.p.m.	No piping was occurring at these locations. Riprap has been placed at the seepage area near the left abutment. These areas have been noted seeping in the past and should be investigated further for the cause. The problems should be properly corrected.
STAFF GAGE AND RECORDER		None	
DRAINS		The toe drain system extends along the toe of the dam with outlets spaced approximately 50 ft. on centers which carry the seepage below the berm. The toe drain outlet at approximate Station 2 + 30 was flowing at an estimated 5 g.p.m. The toe drain outlet at approximate Station 2 + 65 was flowing with less than 1 g.p.m. Other toe drain outlets are non-functional, and have broken pipes and/or are covered with soil. The drains located on both sides of the downstream spillway channel were functional and flowing (less than 1 g.p.m.).	The owner should retain a consultant experienced in earth embankment dams to develop recommendations for the revitalization or reconstruction of the toe drain system in the earth embankment.

OUTLET WORKS

Name of Dam: BRADFORD CITY NO. 2

NDI # PA 00024

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Unaccessible; 20-in. blow-off pipe exits as cast-iron pipe. No cracks or spalling apparent in concrete head wall.	
INTAKE STRUCTURE	Downstream face of intake structure approximately 52 ft. from centerline of dam. Gate house has 5 lift stems: 2 entrance to chamber, 1 blow off, 1 water supply and 1 uncertain. Concrete and brick surfaces of the structure are in fair condition.	Owners indicate blow off is opened bi-annually.
OUTLET STRUCTURE	20-in. blow-off pipe exits through center of dam about 472 ft. from left abutment.	
OUTLET CHANNEL	Outlet channel is relatively free of debris and other obstructions. No serious erosion problems were noted.	
EMERGENCY GATE	20-in. blow-off pipe and gate valve are used for emergency purposes.	

UNGATED SPILLWAY

Name of Dam: BRADFORD CITY NO. 2
 NDI # PA 00024

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Concrete overflow, 69 ft. wide, is located at right (west) end of dam embankment; concrete shows signs of cracking and minor spalling.	Not considered abnormal for age of concrete. Cracks have been patched with asphalt sealer by the Bradford City Water Authority.
APPROACH CHANNEL	Approach channel is free of debris and other obstructions.	Debris is removed periodically by the Bradford City Water Authority.
DISCHARGE CHANNEL	Consists of a concrete channel exiting into rapid flume, which exits into a 22-ft. x 30-ft. stilling basin. Concrete in spillway channel shows cracking and minor spalling from freeze-thaw action. Minor erosion was noted along right bank of stream channel below stilling basin.	The cracks have been filled recently, by the Bradford City Water Authority, with asphalt sealer.
BRIDGE AND PIERS	One 3-ft. wide pier is located at approximate center of spillway crest. The clearance between the spillway crest and bridge deck averages 5.5 ft.	

GATED SPILLWAY (N/A)

Name of Dam: BRADFORD CITY NO. 2

NDI # PA 00024

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL		
APPROACH CHANNEL		
DISCHARGE CHANNEL		
BRIDGE AND PIERS		
GATES AND OPERATION EQUIPMENT		

INSTRUMENTATION

Name of Dam: BRADFORD CITY NO. 2NDI # PA 00024VISUAL EXAMINATIONOBSERVATIONSREMARKS OR RECOMMENDATIONS

MONUMENTATION/SURVEYS

None observed

OBSERVATION WELLS

None observed

WEIRS

None

PIEZOMETERS

None observed

OTHER

N/A

RESERVOIR

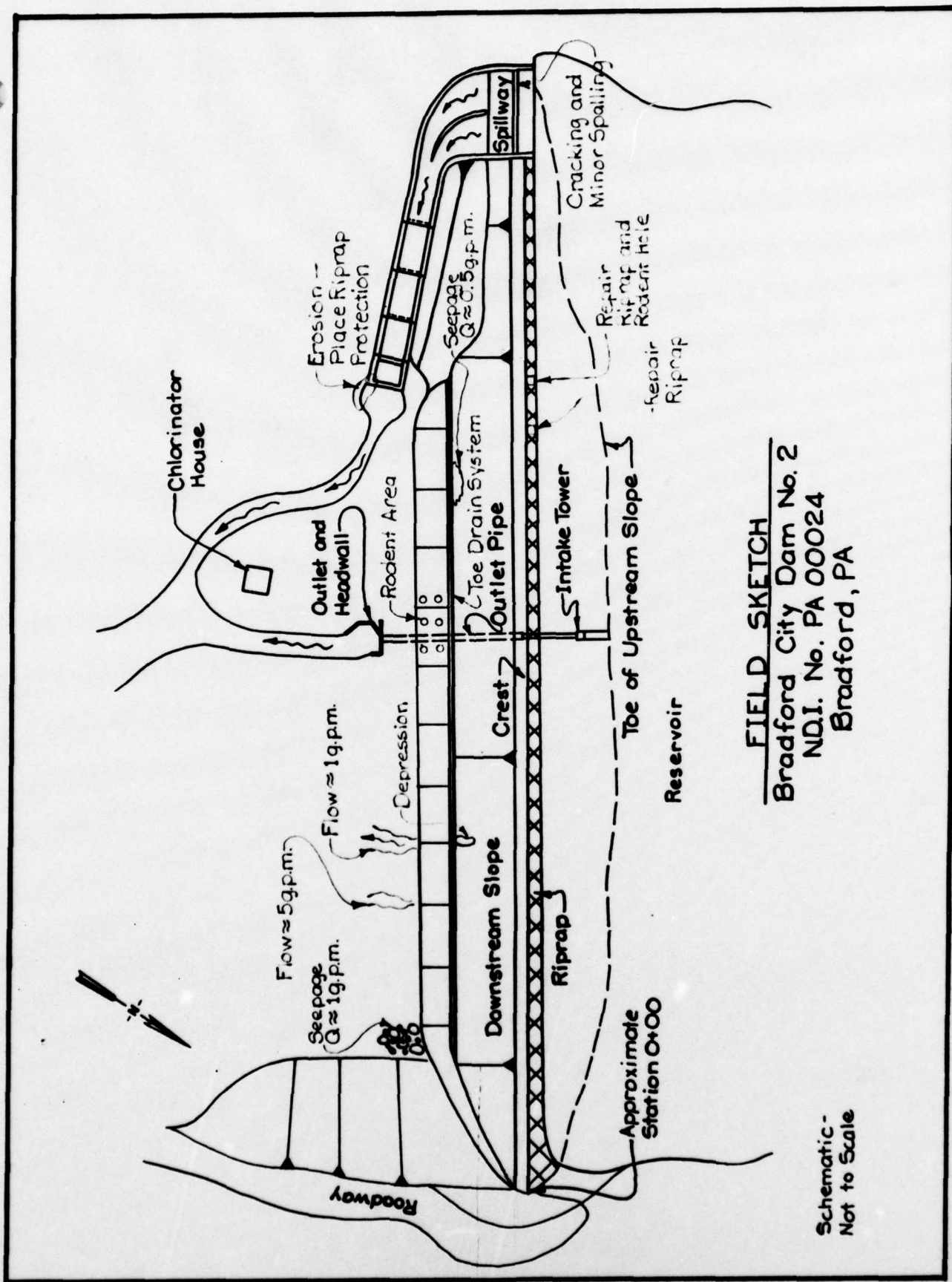
Name of Dam: BRADFORD CITY NO. 2
 NDI # PA 00024

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Heavily wooded; show no sign of sloughing or unusual erosion.	
SEDIMENTATION	No unusual sedimentation was discovered.	

DOWNSTREAM CHANNEL

Name of Dam: BRADFORD CITY NO. 2
 NDI # PA 00024

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Downstream channel is lightly covered with brush and trees (not excessive). Large chunks of concrete in channel, probably from old spillway.	
SLOPES	Right side of channel immediately downstream from stilling pool has substantial erosion.	Recommend protection from erosion by placement of riprap.
APPROXIMATE NO. OF HOMES AND POPULATION	Approximately 15 to 20 homes are located along Gilbert Run downstream of the dam. The confluence of Gilbert Run and Marilla Brook is then located 0.5 miles downstream from the dam. From the confluence, an additional 100 homes are located along Marilla Brook until Marilla Brook joins Tuna Creek an additional 2.5 miles downstream. Tuna Creek then flows through the highly populated City of Bradford.	



APPENDIX B

CHECK LIST - ENGINEERING DATA

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Name of Dam: BRADFORD CITY NO. 2
 NDI # PA 00024

<u>ITEM</u>	<u>REMARKS</u>
PLAN OF DAM	See Plate 4 of this report.
REGIONAL VICINITY MAP	A U.S.G.S. 7.5 minute topographic quadrangle, Bradford, Pennsylvania, was used to prepare the vicinity map which is attached in this report as the Location Plan.
CONSTRUCTION HISTORY	The dam was constructed in 1886 by J. A. Seymore. The embankment was increased in height by 20 ft. in the years 1909 to 1913 under the supervision of A. F. Bannon, Jr.; then City Engineer, while Mr. Wise acted in the capacity of field engineer for the City. North Western Construction Company was contractor for the later construction.

TYPICAL SECTIONS OF DAM See Plates 4 and 5 of this report.

HYDROLOGIC/HYDRAULIC DATA Not available for this inspection report.

OUTLETS - PLAN See Plate 4 of this report.

- **DETAILS** See Plate 4 of this report.

- **CONSTRAINTS** Control of the outlet pipe is located in the gate house tower.

- **DISCHARGE RATINGS** No discharge ratings were available.

RAINFALL/RESERVOIR RECORDS No records available at the dam site.

Name of Dam: BRADFORD CITY NO. 2
 NDI # PA 00024

ITEM	REMARKS
DESIGN REPORTS	No design reports were available.
GEOLOGY REPORTS	No geology reports were available.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY	No design computations of hydrology and hydraulics, or dam stability were available.
SEEPAGE STUDIES	A seepage weir was located downstream from the left end of the dam. This weir was monitored from 1918 to 1928. A new weir was installed in 1933. This new weir was monitored in 1933; however, no information concerning weir readings after 1933 is available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	No information concerning material investigation for design or construction of the existing dam is available. However, a 1933 memorandum in the PemDER file indicates old core drilling records (presumably from the original construction or the increase in height of the embankment) were available at that time. On 20 July 1933, the dam was inspected by an engineer of the Water and Power Resources Board and 3 test pits were examined. The locations were not noted; however, the engineer indicated, "the fill carried a large percentage of clay, with considerable stone and some sand; however, it was poorly placed, leaving the embankment more or less porous due to insufficient rolling or the use of excessively heavy [Reviewer's Note: Thick] layers. Two of the pits showed some seepage from the reservoir."
POST-CONSTRUCTION SURVEYS OF DAM	No post-construction survey information was available.
BORROW SOURCES	No information available.

Name of Dam: BRADFORD CITY NO. 2
 NDI # PA 00024

ITEM	REMARKS
MONITORING SYSTEMS	No monitoring systems are present in the dam. Information concerning a previous seepage weir is discussed on page B-2 under seepage studies.
MODIFICATIONS	<p>In the years 1909 through 1913, the embankment was raised 20 ft. by constructing additional fill on the downstream side of the existing embankment. At this time, a masonry core wall was constructed in the center of the dam (the center of the new dam being 35 ft. downstream from the old dam), and a new spillway was constructed at the right abutment. (The centerline of the old spillway was located 100 ft. from the left abutment of the old dam or 200 ft. from the left abutment of the new embankment.) In 1921, downstream slope of the embankment was changed from 1.5H:1V to 2H:1V. An earth berm was placed at the toe of this slope and the toe drains were extended lateral along the toe with outlets at 50-ft. spacings. The upstream area of the dam and reservoir in the left abutment corner was filled with material to try to stop seepage flow which was occurring through the dam and abutment at this location. In 1933, the seepage weir near the left abutment area of the dam was replaced (the original weir had been installed in 1918), and plans were prepared for the raising of the embankment an additional 15 ft. However, the plans for raising the embankment were never implemented. In 1945, the spillway was repaired and portions of the spillway were replaced. In 1952, the crest of the embankment was restored to the original elevation where settlement and/or erosion had occurred. Additional riprap was placed on the upstream slope at that time.</p>
HIGH POOL RECORDS	No records are available.
POST-CONSTRUCTION ENGINEERING STUDIES AND REPORTS	<p>In 1915, upon initiation of the Water Supply Commission of Pennsylvania (predecessor of PennDER) a "Report Upon the Number 2 Dam of the Bradford Municipal Water Works" was prepared after an inspection of the dam and its appurtenant structures. Since the 1915 inspection, the dam has been inspected an additional 21 times. These inspection reports are available in the PennDER file for this dam.</p>
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	<p>After the height of embankment was increased to 40 ft. in 1913, subsequent sliding and sloughing occurred on the downstream 1.5H:1V slope in the years 1917 (estimated) until the flattening of the slope in 1921. Prior to the replacement of portions of the spillway channel in 1945, the downstream portion was severely undermined and cracked.</p>

Name of Dam: BRADFORD CITY NO. 2
 NDI # PA 00024

ITEM	REMARKS
SPILLWAY PLAN	See Plates 5 and 6 of this report.
SECTIONS	
DETAILS	
OPERATING EQUIPMENT PLANT & DETAILS	No information available.
MAINTENANCE OPERATION RECORDS	No maintenance and operation records are available.

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 4.49 sq.mi. (primarily forested)

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1701 ft. (553 ac.-ft.)

ELEVATION MINIMUM TOP OF DAM (STORAGE CAPACITY): 1705.9 ft. (760 ac.-ft.)

ELEVATION MAXIMUM DESIGN POOL: Unknown

ELEVATION TOP DAM: 1705.9 ft. (minimum elevation)

CREST: Principal Spillway

- a. Elevation 1701 ft.
- b. Type Concrete overflow spillway
- c. Width 68.8 ft.
- d. Length 268 ft. (from spillway crest to stilling basin)
- e. Location Spillover At right abutment
- f. Number and Type of Gates N/A

OUTLET WORKS: 2 - 20-in. concrete pipes (1 - blow-off and 1 - water supply)

- a. Type 20-in. concrete pipe
- b. Location Through embankment approximately 500-ft. from left abutment
- c. Entrance inverts 1664.3 ft. (blow off) 1666.3 ft. (water supply)
- d. Exit inverts 1659.7 ft. (blow off) water supply unknown
- e. Emergency drawdown facilities 20-in. blow-off pipe hand-operated at riser tower

HYDROMETEOROLOGICAL GAGES: Not Applicable

- a. Type _____
- b. Location _____
- c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE Unknown

APPENDIX C

PHOTOGRAPHS

DETAILED PHOTOGRAPH DESCRIPTIONS

Overall View - View From Left Area of Dam Looking Towards the Right Abutment and Spillway Chute

Photo 1 - View of Upstream Crest of Dam
(Intake tower at left-center of photo. Spillway at right-center of photo.)

Photo 2 - View of Downstream Slope of Embankment From Top of Spillway Chute

Photo 3 - View of Spillway Crest and Walkway Over Spillway

Photo 4 - View of Spillway Chute

Photo 5 - View of Spillway Stilling Basin
(Note seepage area in upper left of photo and erosion of right side of stilling basin, center-right of photo.)

Photo 6 - View Looking Upstream at Spillway Chute

Photo 7 - View of Spillway Chute Looking From Toe of Embankment Near Center of Dam

Photo 8 - View of Outlet Pipe and Head Wall

Photo 9 - View of Intake Tower and Walkway

Photo 10 - View of Rock Drain and Seepage Area at Junction of Downstream Toe of Slope and Left Hillside

Photo 11 - View of Depression in Embankment

Photo 12 - View of Toe Drain Outlet
(Flow Approximately 5 g.p.m.)

Note: Photographs were taken on 8 November 1978.

BRADFORD CITY No. 2 DAM

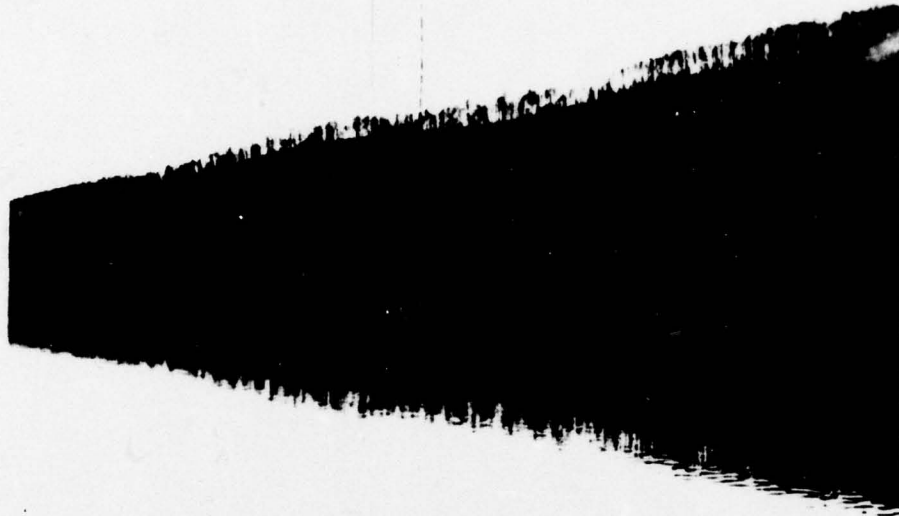
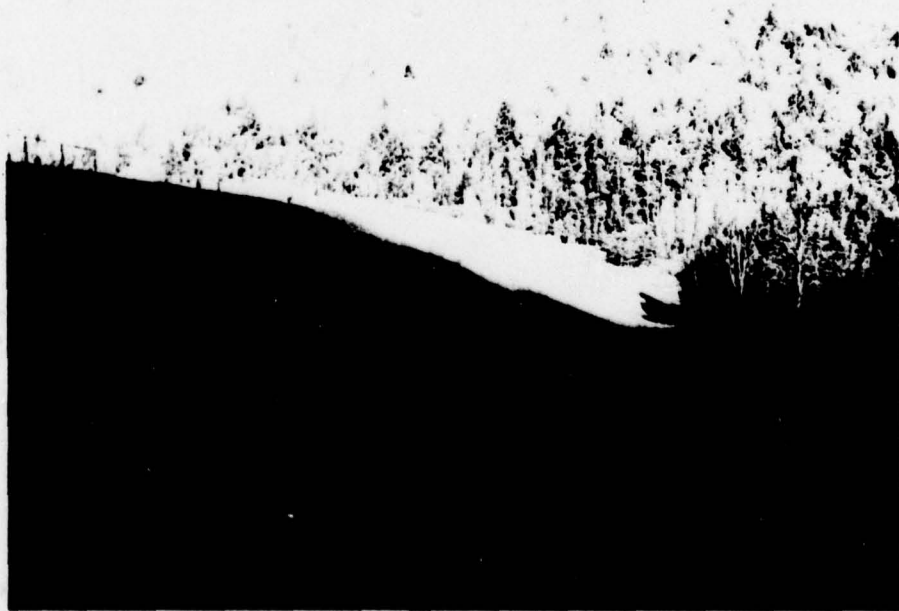


PHOTO 1. View of Upstream Crest of Dam



**PHOTO 2. View of Downstream Slope of Embankment
from Top of Spillway Chute**

BRADFORD CITY No. 2 DAM



PHOTO 3. View of Spillway Chute and Walkway over Spillway



PHOTO 4. View of Spillway Chute

BRADFORD CITY No. 2 DAM



PHOTO 5. View of Spillway Stilling Basin

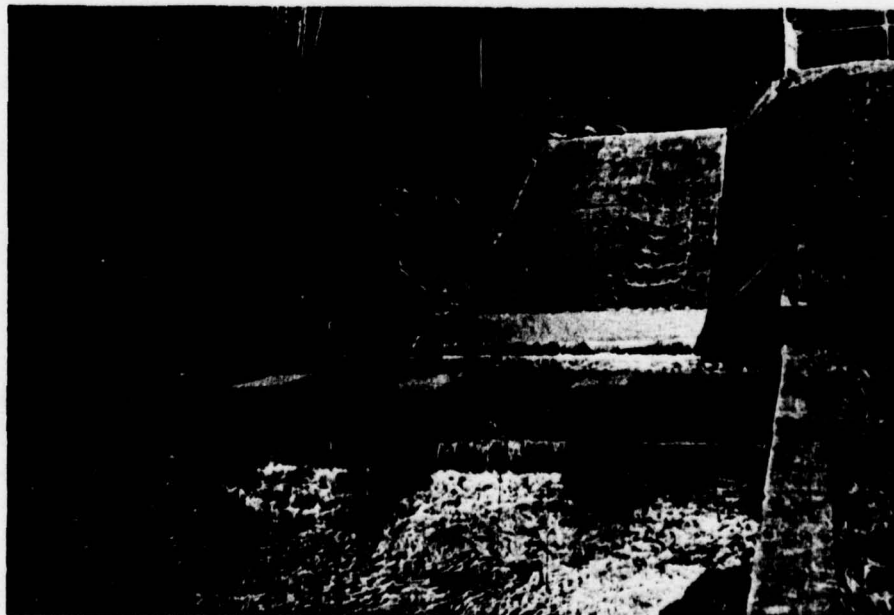


PHOTO 6. View Looking Upstream at Spillway Chute

BRADFORD CITY No. 2 DAM



**PHOTO 7. View of Spillway Chute Looking from Toe of Embankment
Near Center of Dam**

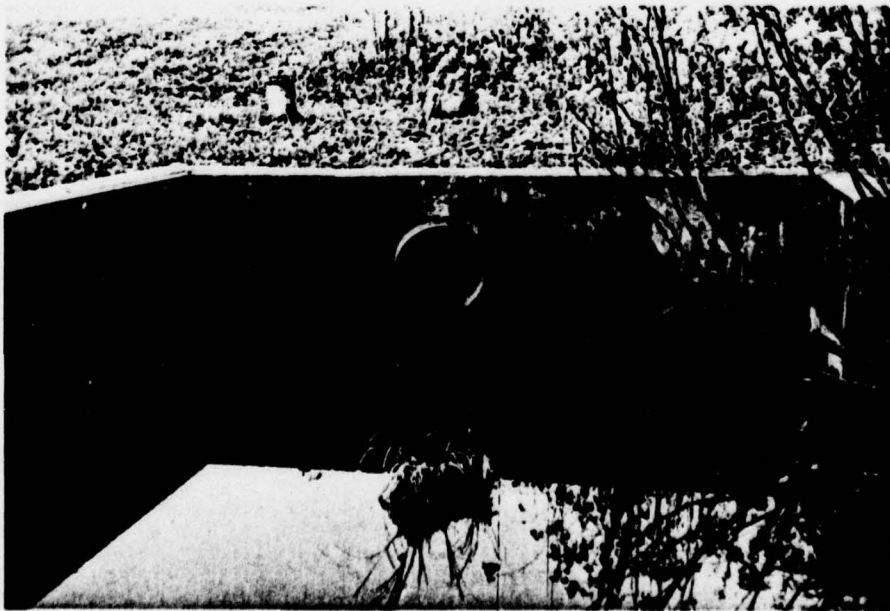


PHOTO 8. View of Outlet Pipe and Head Wall

BRADFORD CITY No. 2 DAM



PHOTO 9. View of Intake Tower and Walkway



**PHOTO 10. View of Rock Drain and Seepage Area at Junction of
Downstream Toe of Slope and Left Hillside**

BRADFORD CITY No. 2 DAM



PHOTO 11. View of Depression in Embankment



PHOTO 12. View of Toe Drain Outlet

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

MICHAEL BAKER, JR., INC.

THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Bradford No. 2

S.O. No. _____

Sheet No. _____ of _____

Drawing No. _____

Computed by _____ Checked by _____ Date _____

Table of Contents

<u>Spillway Rating</u>	<u>1-2</u>
<u>Top of Dam Profile</u>	<u>3</u>
<u>Hydrology</u>	<u>4</u>
<u>Storage and Overlapping Data</u>	<u>5</u>
<u>Damage Area Map</u>	<u>6</u>
<u>Percent passing (PME)</u>	<u>7</u>
<u>Flood Routings</u>	<u>8-13</u>

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject PA Dam Inspections

Bradford City No. 2

Spillway Rating

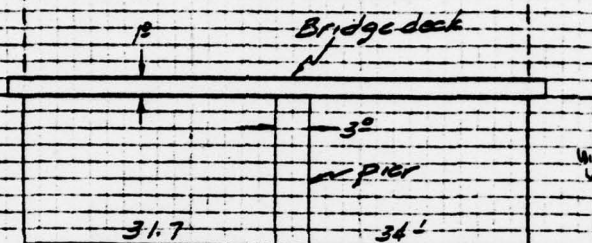
Computed by REH

S.O. No. _____

Sheet No. 1 of 13

Drawing No. _____

Date 12-12-78



Determine effective weir length:

From Design of Small Dams:

$$L = L' - 2(N K_p) H_c$$

L = effective length of crest

L' = Net length of crest

N = number of piers

K_p = pier contraction coefficient

H_c = total head on crest

$$L = 65.8 - 2(1)(0.02)(5.5)$$

$$L = 65.6 \quad (\text{negligible even for max. head})$$

Assuming Critical Depth over spillway:

Q = total flow

$$WSEL = 1701 + EG$$

$$q = Q/65.8$$

$$d_c = \text{critical depth} = \sqrt[3]{Q^2/g}$$

$$A = d_c(65.8)$$

$$V = Q/A$$

$$EG = d_c + V^2/2g \quad (\text{total head})$$

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject PA Dam Inspections

Bradford City No. 2

Spillway Rating

Computed by PEH

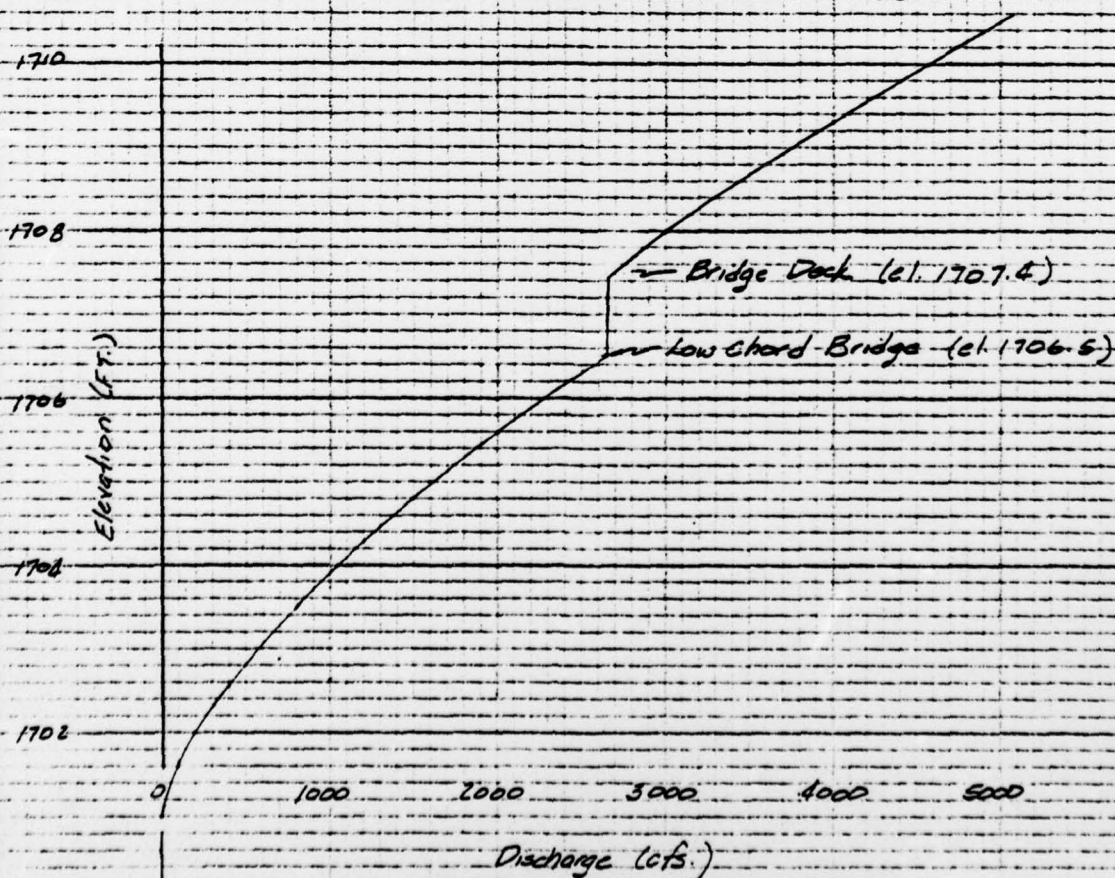
S.O. No. _____

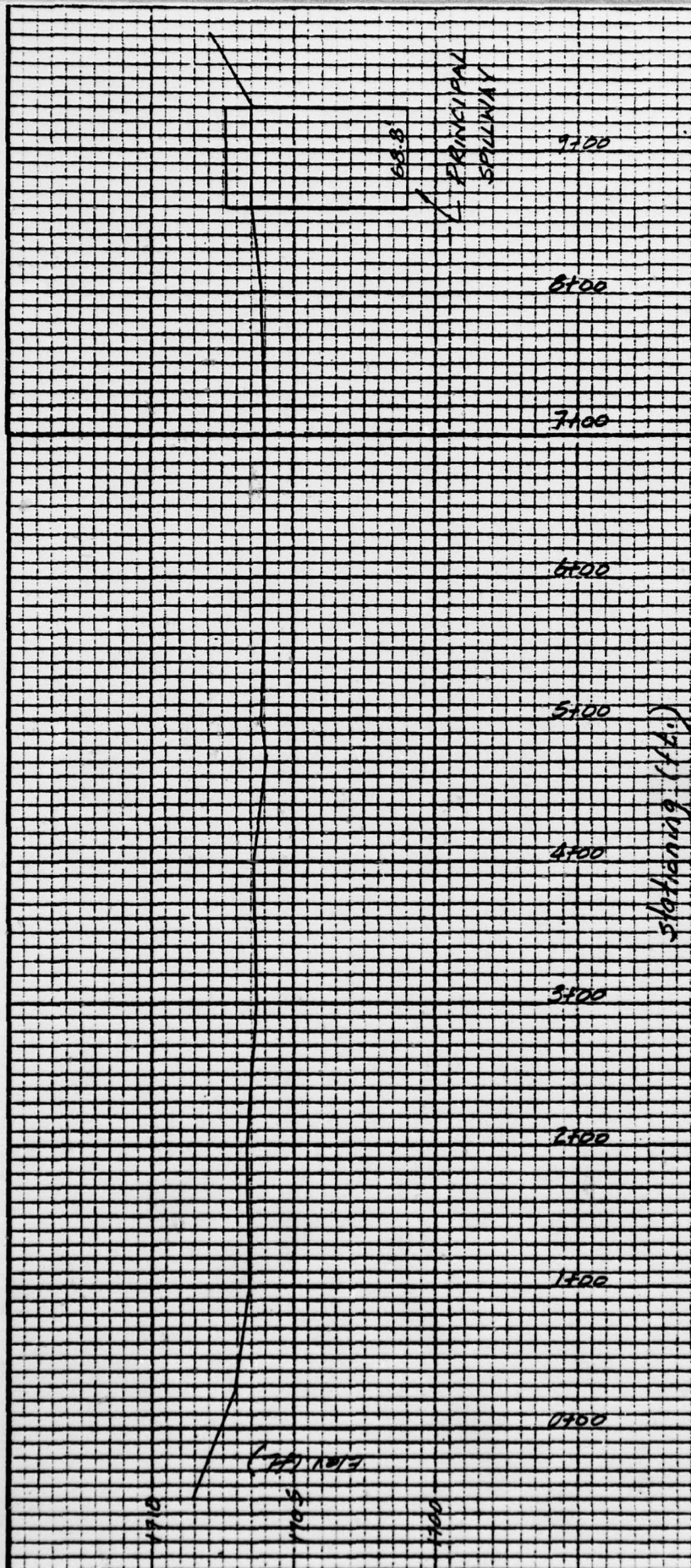
Sheet No. 2 of 13

Drawing No. _____

Date 12-12-78

Q (cfs)	q (cfs/ft)	d_c (ft)	A (ft ²)	V (ft/s)	$V^2/2g$	$E.G.$	$HSEL$
100	1.52	0.42	27.34	3.66	0.21	0.63	1701.63
400	6.08	1.05	68.89	5.81	0.52	1.57	1702.57
800	12.16	1.66	109.35	7.32	0.83	2.49	1703.49
1200	18.24	2.18	143.29	8.37	1.09	3.27	1704.27
1600	24.32	2.64	173.58	9.22	1.32	3.96	1704.96
2000	30.40	3.06	201.42	9.93	1.53	4.59	1705.59
2500	37.99	3.55	233.72	10.70	1.78	5.33	1706.33
3000	45.59	4.01	263.59	11.38	2.01	6.02	1706.92
4000	60.79	4.86	319.71	12.51	2.43	7.29	1707.29
5000	75.99	5.63	370.41	13.50	2.83	8.46	1707.46





Bradford No. 2 Res.

Top of Dam profile

Data taken during
field inspection

Sheet 3 of 13

Average 1706.3
Min. 1705.9

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject NON-FEDERAL DAM INSPECTIONS

BRADFORD No. 2 DAM

SNYDER'S COEFFICIENTS

Computed by DJG

S.O. No. _____

Sheet No. 4 of 13

Drawing No. _____

Date 1-5-79

1) ZONE 23 on Pennsylvania Map

2) $C_p = 0.55$ from table

3) C_L from plate "L" $C_L = 3.3$

$L = 16,350' \approx 3.10 \text{ mi}$ (from WATERSHED MAP)

$L_{CA} = 8230' \approx 1.56 \text{ mi}$ "

4) $t_p = 3.3 [(3.1)(1.56)]^{0.3} = 5.30 \text{ hours}$

5) ADJUST TO EQUIVALENT DURATION 12 min

$$t_p = 5.30 + 0.25 \left(\frac{12}{60} - \frac{3.3}{5.3} \right) = 5.11 \text{ hours}$$

for 12 minute duration

6) $t_p = 5.30 + 0.25 (0.5 - \frac{3.3}{5.3}) = 5.18 \text{ hours (12.40 min.)}$

7) PMF Estimate (from HMT 33)

$P_{10-100} = 22.5 \text{ inches}$

$P_2 = 111\% (P_{10-100})$

$P_{1.2} = 127\% (P_{10-100})$

$P_{0.1} = 141\% (P_{10-100})$

$P_{0.05} = 151\% (P_{10-100})$

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Bradford No. 2 Dam
Storage and Overtopping
Data

Computed by REH Checked by _____

S.O. No. _____

Sheet No. 5 of 13

Drawing No. _____

Date 1-13-79

Stage vs Area (from design plans)

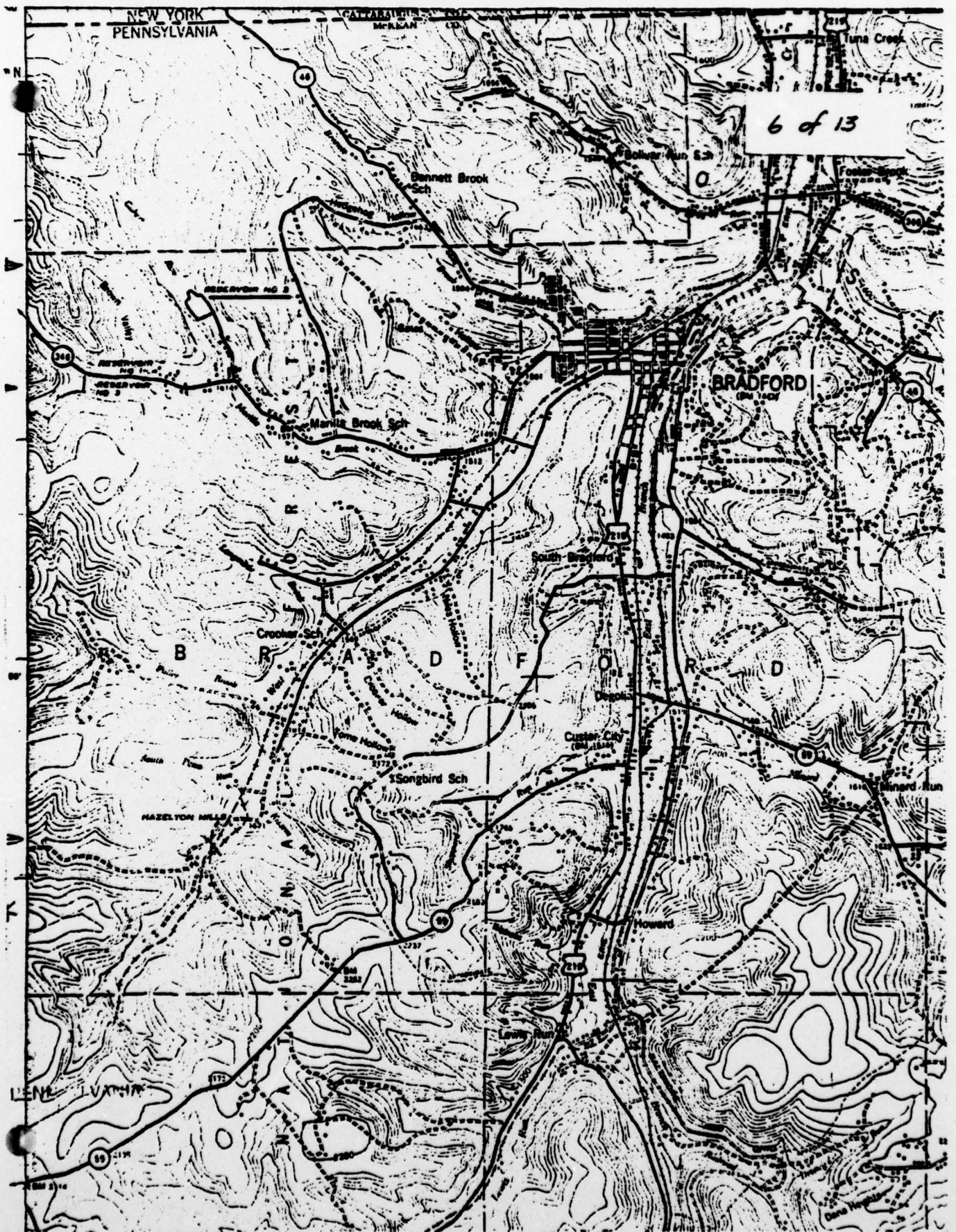
<u>Elev.</u> <u>(ft.)</u>	<u>Area</u> <u>(Ac.)</u>
1661	0
1666	11.6
1671	4.1
1691	22.4
1701	33.6
1706	45.7

Elev. Top of Dam = 1706.5 ft.

Weir coefficient = 2.65

Exponent = 1.5

Length of Dam = 847 ft.



MICHAEL BAKER, JR., INC.

THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject NON-FEDERAL DAM INSPECTIONS

S.O. No. _____

BRADFORD DAM No. 2

Sheet No. 7 of 13

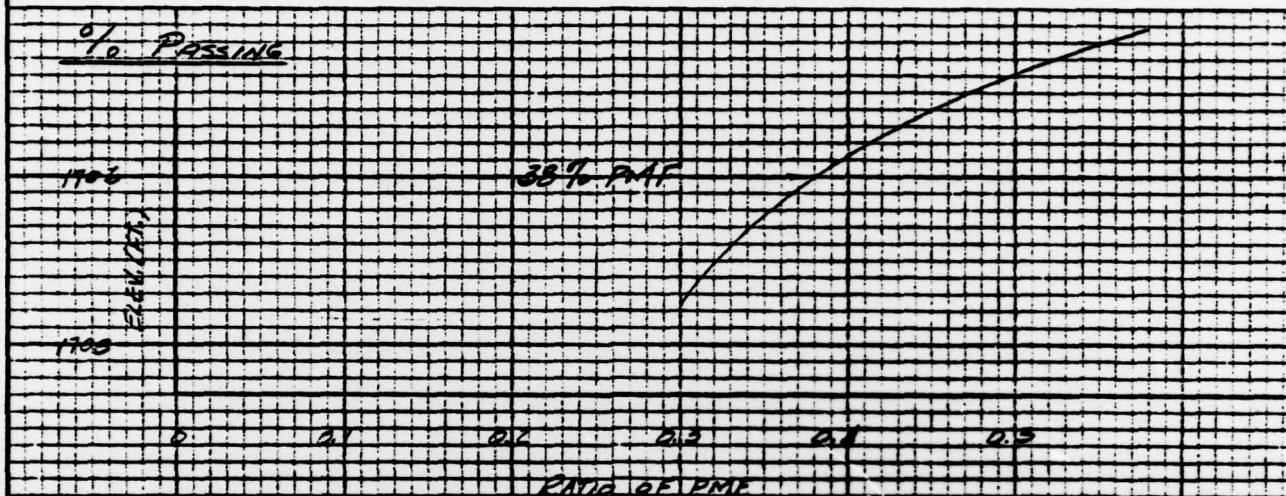
% PMF Passing

Drawing No. _____

Computed by D. J. G.

Checked by _____

Date 1-11-79



No dam breach analysis was performed since the depth of overtopping for 1% PMF would not produce velocities high enough to cause erosion of the crest of the dam.

 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION JULY 1978
 LAST MODIFICATION 25 SEP 78

RUN DATE 02/07/79
 TIME 08.22

NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
 HYDROLOGIC AND HYDRAULIC ANALYSIS OF BRADFORD CITY NO. 2 MRJ 2.0
 PROBABLE MAXIMUM FLOOD PNE/UNIT GRAPH BY SNYDERS METHOD

JOB SPECIFICATION

NO	MR	MMIN	IDAY	IHR	IMIN	MEIRC	IPLT	IPRT	MSIAM
250	0	30	0	0	0	0	0	-4	0
			JUPER	NMT	LROPT	TRACS			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED

NPLAN= 1 NRTIO= 4 LRTIO= 1

RTINS= 1.00 0.50 0.40 0.30

SUB-AREA RUNOFF COMPUTATION

CALCULATION OF INFLOW HYDROGRAPH TO BRADFORD DAM NO. 2

ISTAQ	JCOMP	IECON	ITAPE	IPLT	JPRT	INAME	ISTAGE	IAUTO
PES	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

INVDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISHOW	ISAME	LOCAL
1	1	4.49	0.0	4.49	0.0	0.0	0	1	0

PRECIP DATA

SPFF	PMS	PL	R12	R24	R48	P72	P96
0.0	22.80	117.00	127.00	141.00	151.00	0.0	0.0

TRSPC COMPUTED BY THE PROGRAM IS 0.800

LOSS DATA

LROPT	STKRP	DLTKP	RTIOL	CRAIN	STRKS	RTIOK	STRYL	CHSTL	ALSMV	RTIMP
0	0.0	0.0	1.00	0.0	0.0	1.00	1.00	0.05	0.0	0.0

UNIT HYDROGRAPH DATA

TP= 5.18 CP=0.55 NTA= 0

RECESSION DATA

STATO= -1.50 QOCSN= -0.05 PTIOR= 2.00

UNIT HYDROGRAPH TO END-OF-PERIOD ORDINATES, LAG= 5.19 HOURS, CP= 0.55 VOL= 1.00

9.	32.	66.	105.	148.	193.	236.	270.	295.	311.
314.	302.	280.	257.	237.	218.	201.	185.	170.	156.
144.	133.	122.	112.	103.	95.	88.	81.	74.	68.
63.	58.	53.	49.	45.	41.	38.	35.	32.	30.
27.	25.	23.	21.	20.	18.	17.	15.	14.	13.

9 of 13

12. 5. 11. 5. 10. 4. 9. 4. 9. 4. 8. 3. 7. 3. 7. 3. 6. 3. 6. 2.

MC.DA HR.MN PERIOD RAIN FYCS LOSS COMP Q END-OF-PERIOD FLOW NO.DA HR.MN PERIOD RAIN FYCS LOSS COMP Q

SUM 27.54 25.11 2.43 146237.
1700.11 638.11 62.11 4150.981

HYDROGRAPH ROUTING

ROUTED FLOWS THROUGH BRADFORD DAM NO. 2

ISTAQ ICOMP IECN ITAPE JPLI JPRT INAME ISTAGE IAUTO
DAM 1 0 0 0 0 0 1 0 0

ROUTING DATA
QLOSS CLOSS AVG IRES TSAME IOPT IPMP LSTR
0.0 0.0 0.0 1 1 0 0

NSTPS NSTOL LAG AMSKK Y TSK STORA ISPRAT
1 0 0 0.0 0.0 0.0 -1701. -1

STAGE 1701.00 1701.60 1702.60 1703.50 1704.30 1705.00 1705.60 1706.30 1706.50 1707.50
1708.00 1709.30 1710.50

FLOW 0.0 100.00 400.00 800.00 1200.00 1600.00 2000.00 2500.00 2650.00 2650.00
3000.00 4000.00 5000.00

SURFACE AREA= 0. 1. 4. 22. 39. 46.
CAPACITY= 0. 1. 11. 252. 553. 764.

ELEVATION= 1661. 1666. 1671. 1691. 1701. 1706.

CREL SPHID CQW FYPW FLEV COOL CAPEA EYPL
1701.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

DAM DATA
TOPEL CQW EYPD DAMWID
1706.3 2.6 1.5 847.

WARNING *** TOP OF DAM, BOTTOM OF BREACH, OR LOW-LEVEL OUTLET IS NOT WITHIN RANGE OF GIVEN ELEVATIONS IN STORAGE-ELEVATION DATA
BOTTOM OF RESERVOIR ASSUMED TO BE AT 1661.00
STORAGE-ELEVATION DATA WILL BE EXTRAPOLATED ABOVE ELEVATION 1706.00

PEAK OUTFLOW IS 6073. AT TIME 45.00 HOURS

WARNING *** TOP OF DAM, BOTTOM OF BREACH, OR LOW-LEVEL OUTLET IS NOT WITHIN RANGE OF GIVEN ELEVATIONS IN STORAGE-ELEVATION DATA
BOTTOM OF RESERVOIR ASSUMED TO BE AT 1661.00
STORAGE-ELEVATION DATA WILL BE EXTRAPOLATED ABOVE ELEVATION 1706.00

PEAK OUTFLOW IS 3026. AT TIME 45.00 HOURS

WARNING *** TOP OF DAM, BOTTOM OF BREACH, OR LOW-LEVEL OUTLET IS NOT WITHIN RANGE OF GIVEN ELEVATIONS IN STORAGE-ELEVATION DATA
BOTTOM OF RESERVOIR ASSUMED TO BE AT 1661.00
STORAGE-ELEVATION DATA WILL BE EXTRAPOLATED ABOVE ELEVATION 1706.00

10 of 13

PEAK OUTFLOW IS 2363. AT TIME 45.50 HOURS

WARNING *** TOP OF DAM, BOTTOM OF REACH, OR LOW-LEVEL OUTLET IS NOT WITHIN RANGE OF GIVEN ELEVATIONS IN STORAGE-ELEVATION DATA
BOTTOM OF RESERVOIR ASSUMED TO BE AT 1661.00
STORAGE-ELEVATION DATA WILL BE EXTRAPOLATED ABOVE ELEVATION 1706.00

PEAK OUTFLOW IS 1762. AT TIME 45.50 HOURS

11 of 13

REVON / FORM 1411-4, Q1

PRINTED IN U.S.A.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION STATION AREA PLAN PATIO 1 RATIO 2 RATIO 3 RATIO 4
 1.00 0.50 0.40 0.30

HYDROGRAPH AT RES 4.49 1 6066 3033 2427 1820
 (11.63) (171.78) (85.89) (68.71) (51.54)
 ROUTED TO DAM 4.49 1 6073 3026 2363 1762
 (11.63) (171.95) (85.68) (66.92) (49.89)

12 of 13

E

| PLAN 1 | | | | | | | | | | INITIAL VALUE | | SPILLWAY CREST | | AVERAGE | | MINIMUM | |
|--------------|------|------|--------|------|------|------|------|------|------|----------------|------|----------------|-------|----------|-------|---------|-----|
| ELEVATION | | | | | | | | | | 1701.00 | | 1701.00 | | 1706.30 | | 1705.9 | |
| STORAGE | | | | | | | | | | 553. | | 553. | | 178. | | | |
| OUTFLOW | | | | | | | | | | 0. | | 0. | | 2500. | | | |
| | | | | | | | | | | RELATIVE DEPTH | | | | | | | |
| PATIO | | | | | | | | | | AVERAGE | | MAXIMUM | | DURATION | | TIME OF | |
| OF | | | | | | | | | | DEPTH | | STORAGE | | OVER TOP | | FAILURE | |
| PMF | | | | | | | | | | OVER DAM | | AC-FT | | HOURS | | HOURS | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1.31 | 1.71 | 839. | 6073. | 11.00 | 45.00 | 0.0 | 0.0 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 0.30 | 0.70 | 792. | 3026. | 3.50 | 45.00 | 0.0 | 0.0 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 0.0 | 0.21 | 769. | 2363. | 0.0 | 45.50 | 0.0 | 0.0 |
| 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 0.30 | 0.20 | 730. | 1762. | 0.0 | 45.50 | 0.0 | 0.0 |
| 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | | | | | | | | |
| 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | | | | | | | | |
| 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | | | | | | | | |
| 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | | | | | | | | |
| 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | | | | | | | | |
| 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | | | | | | | | |
| 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | | | | | | | | |
| 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | | | | | | | | |
| 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 | 129 | 130 | | | | | | | | |
| 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 | | | | | | | | |
| 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 | | | | | | | | |
| 151 | 152 | 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 | | | | | | | | |
| 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 | | | | | | | | |
| 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 | | | | | | | | |
| 181 | 182 | 183 | 184 | 185 | 186 | 187 | 188 | 189 | 190 | | | | | | | | |
| 191 | 192 | 193 | 194 | 195 | 196 | 197 | 198 | 199 | 200 | | | | | | | | |
| 201 | 202 | 203 | 204 | 205 | 206 | 207 | 208 | 209 | 210 | | | | | | | | |
| 211 | 212 | 213 | 214 | 215 | 216 | 217 | 218 | 219 | 220 | | | | | | | | |
| 221 | 222 | 223 | 224 | 225 | 226 | 227 | 228 | 229 | 230 | | | | | | | | |
| 231 | 232 | 233 | 234 | 235 | 236 | 237 | 238 | 239 | 240 | | | | | | | | |
| 241 | 242 | 243 | 244 | 245 | 246 | 247 | 248 | 249 | 250 | | | | | | | | |
| 251 | 252 | 253 | 254 | 255 | 256 | 257 | 258 | 259 | 260 | | | | | | | | |
| 261 | 262 | 263 | 264 | 265 | 266 | 267 | 268 | 269 | 270 | | | | | | | | |
| 271 | 272 | 273 | 274 | 275 | 276 | 277 | 278 | 279 | 280 | | | | | | | | |
| 281 | 282 | 283 | 284 | 285 | 286 | 287 | 288 | 289 | 290 | | | | | | | | |
| 291 | 292 | 293 | 294 | 295 | 296 | 297 | 298 | 299 | 300 | | | | | | | | |
| 301 | 302 | 303 | 304 | 305 | 306 | 307 | 308 | 309 | 310 | | | | | | | | |
| 311 | 312 | 313 | 314 | 315 | 316 | 317 | 318 | 319 | 320 | | | | | | | | |
| 321 | 322 | 323 | 324 | 325 | 326 | 327 | 328 | 329 | 330 | | | | | | | | |
| 331 | 332 | 333 | 334 | 335 | 336 | 337 | 338 | 339 | 340 | | | | | | | | |
| 341 | 342 | 343 | 344 | 345 | 346 | 347 | 348 | 349 | 350 | | | | | | | | |
| 351 | 352 | 353 | 354 | 355 | 356 | 357 | 358 | 359 | 360 | | | | | | | | |
| 361 | 362 | 363 | 364 | 365 | 366 | 367 | 368 | 369 | 370 | | | | | | | | |
| 371 | 372 | 373 | 374 | 375 | 376 | 377 | 378 | 379 | 380 | | | | | | | | |
| 381 | 382 | 383 | 384 | 385 | 386 | 387 | 388 | 389 | 390 | | | | | | | | |
| 391 | 392 | 393 | 394 | 395 | 396 | 397 | 398 | 399 | 400 | | | | | | | | |
| 401 | 402 | 403 | 404 | 405 | 406 | 407 | 408 | 409 | 410 | | | | | | | | |
| 411 | 412 | 413 | 414 | 415 | 416 | 417 | 418 | 419 | 420 | | | | | | | | |
| 421 | 422 | 423 | 424 | 425 | 426 | 427 | 428 | 429 | 430 | | | | | | | | |
| 431 | 432 | 433 | 434 | 435 | 436 | 437 | 438 | 439 | 440 | | | | | | | | |
| 441 | 442 | 443 | 444 | 445 | 446 | 447 | 448 | 449 | 450 | | | | | | | | |
| 451 | 452 | 453 | 454 | 455 | 456 | 457 | 458 | 459 | 460 | | | | | | | | |
| 461 | 462 | 463 | 464 | 465 | 466 | 467 | 468 | 469 | 470 | | | | | | | | |
| 471 | 472 | 473 | 474 | 475 | 476 | 477 | 478 | 479 | 480 | | | | | | | | |
| 481 | 482 | 483 | 484 | 485 | 486 | 487 | 488 | 489 | 490 | | | | | | | | |
| 491 | 492 | 493 | 494 | 495 | 496 | 497 | 498 | 499 | 500 | | | | | | | | |
| 501 | 502 | 503 | 504 | 505 | 506 | 507 | 508 | 509 | 510 | | | | | | | | |
| 511 | 512 | 513 | 514 | 515 | 516 | 517 | 518 | 519 | 520 | | | | | | | | |
| 521 | 522 | 523 | 524 | 525 | 526 | 527 | 528 | 529 | 530 | | | | | | | | |
| 531 | 532 | 533 | 534 | 535 | 536 | 537 | 538 | 539 | 540 | | | | | | | | |
| 541 | 542 | 543 | 544 | 545 | 546 | 547 | 548 | 549 | 550 | | | | | | | | |
| 551 | 552 | 553 | 554 | 555 | 556 | 557 | 558 | 559 | 560 | | | | | | | | |
| 561 | 562 | 563 | 564 | 565 | 566 | 567 | 568 | 569 | 570 | | | | | | | | |
| 571 | 572 | 573 | 574 | 575 | 576 | 577 | 578 | 579 | 580 | | | | | | | | |
| 581 | 582 | 583 | 584 | 585 | 586 | 587 | 588 | 589 | 590 | | | | | | | | |
| 591 | 592 | 593 | 594 | 595 | 596 | 597 | 598 | 599 | 600 | | | | | | | | |
| 601 | 602 | 603 | 604 | 605 | 606 | 607 | 608 | 609 | 610 | | | | | | | | |
| 611 | 612 | 613 | 614 | 615 | 616 | 617 | 618 | 619 | 620 | | | | | | | | |
| 621 | 622 | 623 | 624 | 625 | 626 | 627 | 628 | 629 | 630 | | | | | | | | |
| 631 | 632 | 633 | 634 | 635 | 636 | 637 | 638 | 639 | 640 | | | | | | | | |
| 641 | 642 | 643 | 644 | 645 | 646 | 647 | 648 | 649 | 650 | | | | | | | | |
| 651 | 652 | 653 | 654 | 655 | 656 | 657 | 658 | 659 | 660 | | | | | | | | |
| 661 | 662 | 663 | 664 | 665 | 666 | 667 | 668 | 669 | 670 | | | | | | | | |
| 671 | 672 | 673 | 674 | 675 | 676 | 677 | 678 | 679 | 680 | | | | | | | | |
| 681 | 682 | 683 | 684 | 685 | 686 | 687 | 688 | 689 | 690 | | | | | | | | |
| 691 | 692 | 693 | 694 | 695 | 696 | 697 | 698 | 699 | 700 | | | | | | | | |
| 701 | 702 | 703 | 704 | 705 | 706 | 707 | 708 | 709 | 710 | | | | | | | | |
| 711 | 712 | 713 | 714 | 715 | 716 | 717 | 718 | 719 | 720 | | | | | | | | |
| 721 | 722 | 723 | 724 | 725 | 726 | 727 | 728 | 729 | 730 | | | | | | | | |
| 731 | 732 | 733 | 734 | 735 | 736 | 737 | 738 | 739 | 740 | | | | | | | | |
| 741 | 742 | 743 | 744 | 745 | 746 | 747 | 748 | 749 | 750 | | | | | | | | |
| 751 | 752 | 753 | 754 | 755 | 756 | 757 | 758 | 759 | 760 | | | | | | | | |
| 761 | 762 | 763 | 764 | 765 | 766 | 767 | 768 | 769 | 770 | | | | | | | | |
| 771 | 772 | 773 | 774 | 775 | 776 | 777 | 778 | 779 | 780 | | | | | | | | |
| 781 | 782 | 783 | 784 | 785 | 786 | 787 | 788 | 789 | 790 | | | | | | | | |
| 791 | 792 | 793 | 794 | 795 | 796 | 797 | 798 | 799 | 800 | | | | | | | | |
| 801 | 802 | 803 | 804 | 805 | 806 | 807 | 808 | 809 | 810 | | | | | | | | |
| 811 | 812 | 813 | 814 | 815 | 816 | 817 | 818 | 819 | 820 | | | | | | | | |
| 821 | 822 | 823 | 824 | 825 | 826 | 827 | 828 | 829 | 830 | | | | | | | | |
| 831 | 832 | 833 | 834 | 835 | 836 | 837 | 838 | 839 | 840 | | | | | | | | |
| 841 | 842 | 843 | 844 | 845 | 846 | 847 | 848 | 849 | 850 | | | | | | | | |
| 851 | 852 | 853 | 854 | 855 | 856 | 857 | 858 | 859 | 860 | | | | | | | | |
| 861 | 862 | 863 | 864 | 865 | 866 | 867 | 868 | 869 | 870 | | | | | | | | |
| 871 | 872 | 873 | 874 | 875 | 876 | 877 | 878 | 879 | 880 | | | | | | | | |
| 881 | 882 | 883 | 884 | 885 | 886 | 887 | 888 | 889 | 890 | | | | | | | | |
| 891 | 892 | 893 | 894 | 895 | 896 | 897 | 898 | 899 | 900 | | | | | | | | |
| 901 | 902 | 903 | 904 | 905 | 906 | 907 | 908 | 909 | 910 | | | | | | | | |
| 911 | 912 | 913 | 914 | 915 | 916 | 917 | 918 | 919 | 920 | | | | | | | | |
| 921 | 922 | 923 | 924 | 925 | 926 | 927 | 928 | 929 | 930 | | | | | | | | |
| 931 | 932 | 933 | 934 | 935 | 936 | 937 | 938 | 939 | 940 | | | | | | | | |
| 941 | 942 | 943 | 944 | 945 | 946 | 947 | 948 | 949 | 950 | | | | | | | | |
| 951 | 952 | 953 | 954 | 955 | 956 | 957 | 958 | 959 | 960 | | | | | | | | |
| 961 | 962 | 963 | 964 | 965 | 966 | 967 | 968 | 969 | 970 | | | | | | | | |
| 971 | 972 | 973 | 974 | 975 | 976 | 977 | 978 | 979 | 980 | | | | | | | | |
| 981 | 982 | 983 | 984 | 985 | 986 | 987 | 988 | 989 | 990 | | | | | | | | |
| 991 | 992 | 993 | 994 | 995 | 996 | 997 | 998 | 999 | 1000 | | | | | | | | |
| 1001 | 1002 | 1003 | 1004 | 1005 | 1006 | 1007 | 1008 | 1009 | 1010 | | | | | | | | |
| 1011 | 1012 | 1013 | 1014 | 1015 | 1016 | 1017 | 1018 | 1019 | 1020 | | | | | | | | |
| 1021 | 1022 | 1023 | 1024</ | | | | | | | | | | | | | | |

APPENDIX E

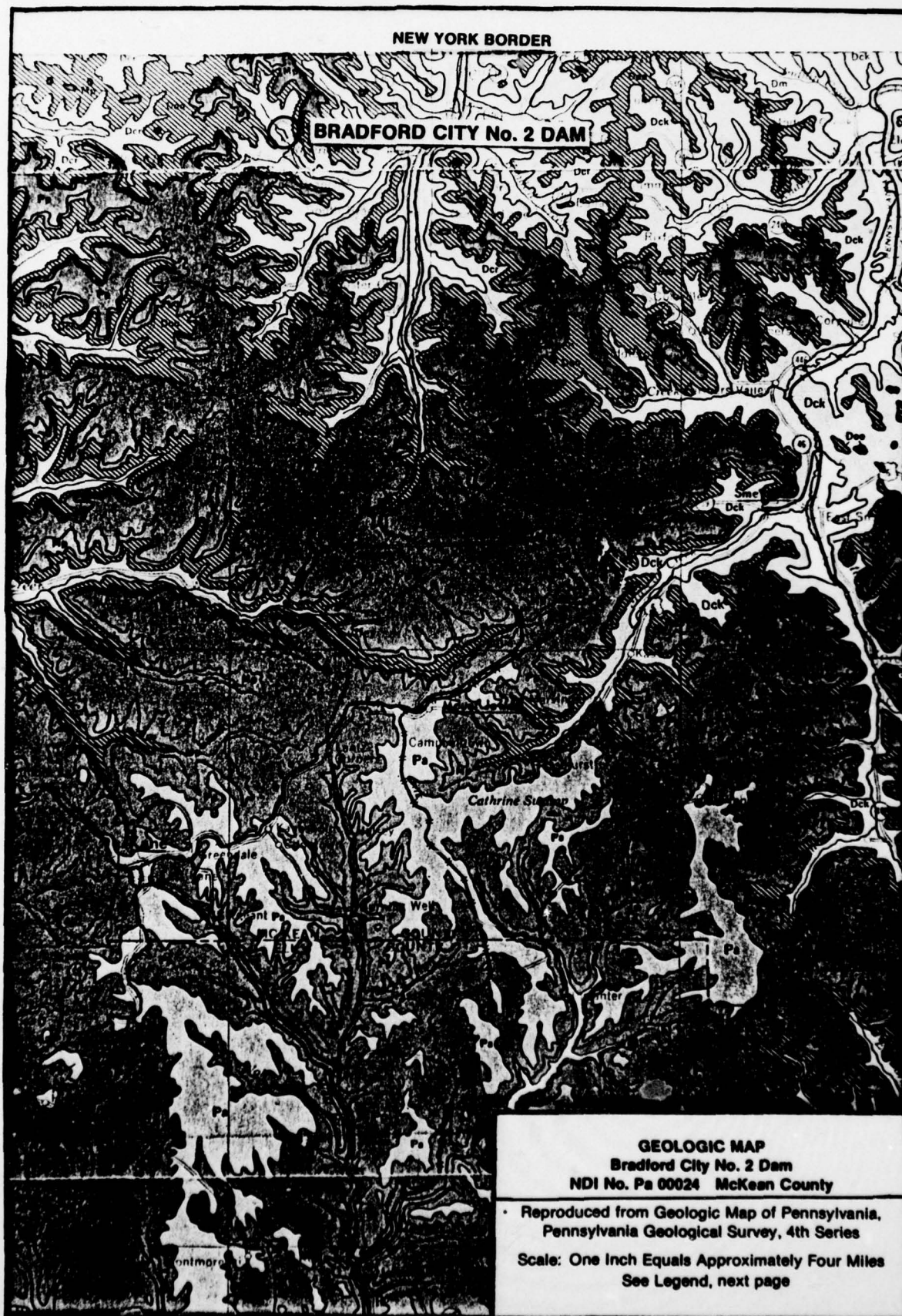
REGIONAL GEOLOGY

BRADFORD CITY NO. 2 DAM
NDI NO. PA 00024, PennDER No. 42-8

REGIONAL GEOLOGY

Bradford City No. 2 Dam is located in the unglaciated section of the northern portion of the Appalachian Plateaus physiographic province. Bedrock units are members of the Cattaraugus formation of the Upper Devonian system which are typically red, gray and brown sandstones and shales. These strata are essentially horizontal with gentle regional folding. References do not indicate any faulting in the vicinity of the dam.

Although the area has not been glaciated, the dam is located a short distance upstream from the relatively thick glacial stream and lake deposits which fill the valleys of Tunungwant (Tuna) Creek and its tributaries. However, it appears that most the dam and reservoir are located on residual soils of the Allegheny-Dekalb soil group which reportedly average about 4 feet in thickness. A small amount of alluvium may be present.



LEGEND

PERMIAN



Greene Formation

Cyclic sequences of sandstone, shale, red beds, limestone and coal; base at the top of the Upper Washington Limestone.

PERMIAN AND PENNSYLVANIAN



Washington Formation

Cyclic sequences of sandstone, shale, limestone and coal; some red shale; some mineable coal; base at the top of the Waynesburg Coal.

PENNSYLVANIAN

APPALACHIAN PLATEAU



Monongahela Formation

Cyclic sequences of sandstone, shale, limestone and coal; limestone prominent in northern outcrop areas; shale and sandstone increase southward; commercial coals present; base at the bottom of the Pittsburgh Coal.



Conemaugh Formation

Cyclic sequences of red and gray shales and siltstones with thin limestones and coals; massive Mahoning Sandstone commonly present at base; Ames Limestone present in middle of section; Brush Creek Limestone in lower part of section.



Allegheny Group

Cyclic sequences of sandstone, shale, limestone and coal; numerous commercial coals; limestones thicken westward; Vanport Limestone in lower part of section; includes Freeport, Kiskadee, and Clarion Formations.



Pottsville Group

Predominantly sandstones and conglomerates with thin shales and coals; some coals mineable locally.

ANTHRACITE REGION



Post-Pottsville Formations

Brown or gray sandstones and shales with some conglomerate and numerous mineable coals.



Pottsville Group

Light gray to white, coarse grained sandstones and conglomerates with some mineable coal; includes Sharp Mountain, Schuylkill, and Tumbling Run Formations.

MISSISSIPPIAN



Mauch Chunk Formation

Red shales with brown to greenish gray flaggy sandstones; includes Greenbrier Limestone in Fayette, Westmoreland, and Somerset counties; Logan Limestone at the base in southwestern Pennsylvania.



Pocono Group

Predominantly gray, hard, massive, cross-bedded conglomerate and sandstone with some shale; includes in the Appalachian Plateau Burgoon, Shenango, Cuyahoga, Cussewago, Corry, and Knapp Formations; includes part of "Onaway" of M. L. Fuller in Potter and Tioga counties.

DEVONIAN UPPER

WESTERN PENNSYLVANIA



Onaway Formation

Greenish gray to gray shales, siltstones and sandstones becoming increasingly shaly westward; considered equivalent to type Onaway, Riceville Formation Or in Erie and Crawford Counties; probably not distinguishable north of Corry.



Cattaraugus Formation

Red, gray and brown shale and sandstone with the proportion of red decreasing westward; includes Venango beds of drillers and Salamanca sandstone and conglomerate; some limestone in Crawford and Erie counties.



Conneaut Group

Alternating gray, brown, greenish and purplish shales and siltstones; includes "pink-rock" of drillers and "Chemung" and "Girard" Formations of northwestern Pennsylvania.



Canadaway Formation

Alternating brown shales and sandstones; includes "Portage" Formation of northwestern Pennsylvania.